PUBLISHED BY THE INSTITUTE OF FOOD TECHNOLOGISTS

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# Affairs of the Institute

Annual Meeting Bulletin Board
Regional Section News
Personnel
Selected Abstracts
Books
Future Meetings
Recently Elected Members
Food Industry Topics

## Annual Meeting Bulletin Board

**Entertainment for 1955 I. F. T. Meeting.** The entertainment planned for the Columbus IFT meeting (June 12-16, 1955) according to A. R. Winter, Entertainment Chairman, includes a mixer, beef barbecue and water follies show. The mixer will be held Sunday night, June 12 at the Deshler Hilton Hotel. It will follow the same pattern of previous mixers.

Following the Monday afternoon sessions, buses will pick up members and guests at the headquarters hotel for a trip to Ohio State University stadium where a beef barbecue will be served. Professor L. E. Kunkle of the Animal Science Department at the University will be in charge of the barbecue. Members and guests will be able to see how the meat is barbecued and served. Professor Kunkle and his associates have served as high as 20,000 people at a single barbecue. They will serve us beef that will be something to write home about.

**The Ohio State University Stadium**

A water follies will be staged in the beautiful and spacious natatorium following the barbecue. It is only a short block from the stadium. The program will be staged by Coach Mike Peppe who has won many swimming and diving championships with his team. Mike has promised to have some world record holders, both men and women, on the program. He will also present novelty and swan club acts. The biggest splash and one of the most interesting races will include well known IFT talent.

Buses will return members and guests to down-town headquarters following the barbecue and/or the follies show. Ample parking space will be available for those who wish to drive their own cars.

**The Women's Program.** Columbus is getting out its best bib-and-tucker in anticipation of the arrival of the members of the Institute of Food Technologists and it is hoped they will bring the ladies along. The committee promises to be nice to the weatherman and arrange to parade in honor of our guests whatever is best in food, in flowers, in tradition, and in beguiling personalities in central Ohio. Dr. Inez Prudent, chairman of the Women's Entertainment, stated "The telephone lines have been humming for weeks with schemes and schedules."

A tea Sunday afternoon in the women's headquarters on the twelfth floor of the Deshler-Hilton Hotel will give the women members of the Ohio Valley Section of the IFT and the wives of OVIFT members an opportunity to get acquainted with their guests. We hope these rooms will serve all during the convention as a convenient meeting place to join friends, as an information center, and as a leisure-time activity center. Here will be the daily paper, a Band Aid, or a fourth person for a rubber of bridge.

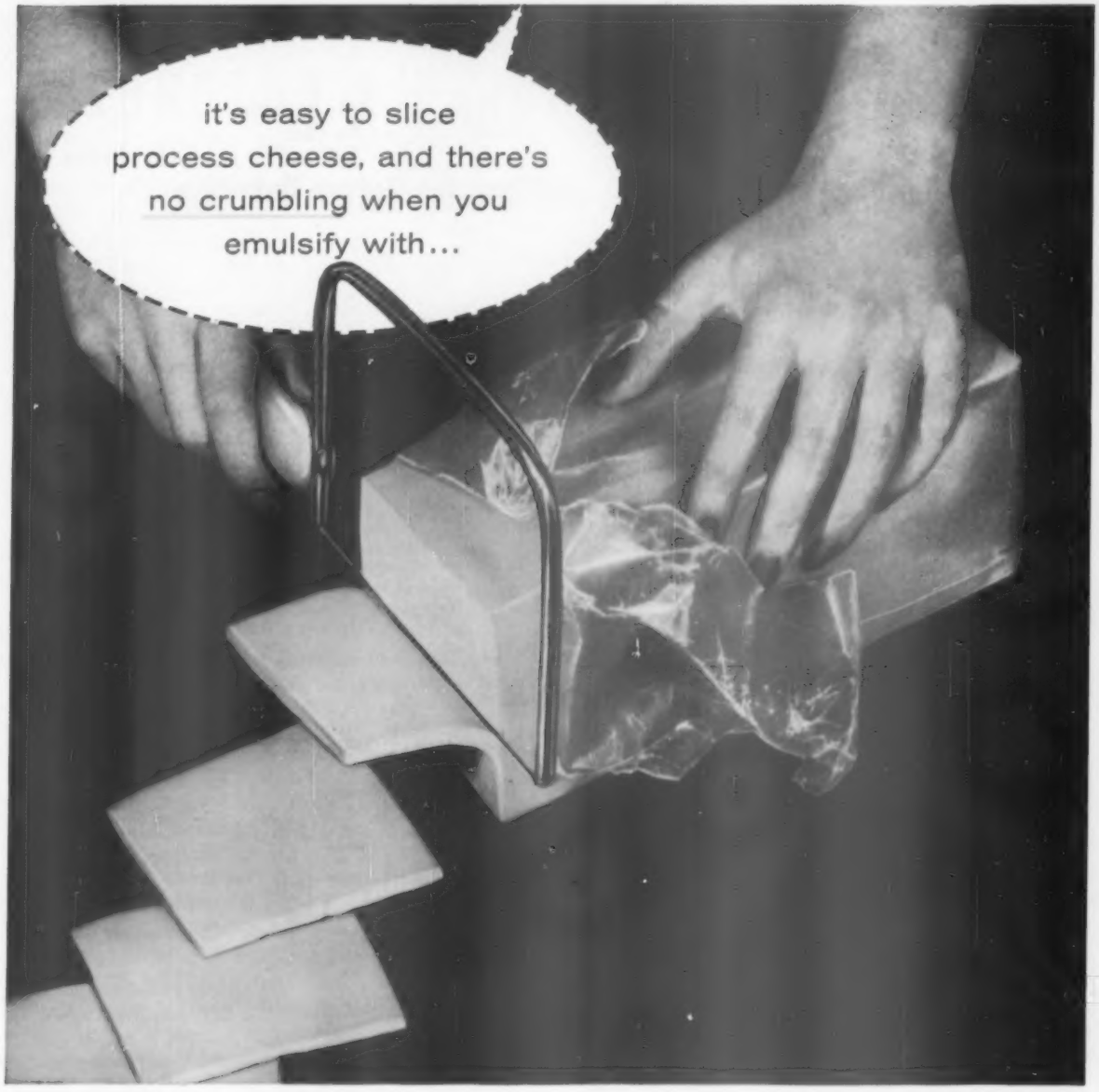
Each morning, after a mid-morning snack at 9:30 or 10:00, a subject of particular interest to women will be presented by a well-recognized authority. On Monday the owner of a gift shop in downtown Columbus, replete with unique and charming art treasures, will describe some of her adventures and friends in art circles. Because Ohio is a center for the ceramic industries, it seems fitting that on Tuesday morning the story of the origin and development of designs for fine tableware should be told by a designer who is responsible for the patterns, shapes and colors of dishes made by a leading Ohio Valley manufacturer. On Wednesday a representative of a major concern in the spice and herb trade will bring to his audience some of the fascinating lore of these foods.

A trip has been planned by bus across the peaceful and prosperous Ohio countryside to Lebanon for a glimpse into the riches of the Ohio heritage. Late on Monday morning, but in time to reach the Golden Lamb for lunch, those who wish to make the tour will leave the headquarters hotel, bound for the venerable city of Lebanon. After lunch at the historic old inn the group will drive to Glendower, a recently restored early American home which is the pride and joy of the Ohio Historical Society. On the way back to Columbus the busses will stop briefly so the visitors may look over the extensive earthworks and take a glance at some of the mementos at Fort Ancient. The busses will get back to the hotel early enough for the travellers to take a short rest before going to the OSU stadium for the big barbecue and swimming meet.

For wonderful food and generous hospitality, central Ohio has nothing to compare with Ilonka's Party house where a luncheon has been planned for Tuesday noon. In the afternoon the lady herself will beguile her audience with tales of her adventures in search of the exotic in foods in many far countries. Later in the afternoon the group will visit the Columbus Rose Garden which should be at the height of its splendor.

No visit to Columbus would be complete without a meal at the Maramor, named for its founder, Mary Love, and known throughout its history for the highest standards of quality in food and service. Accordingly,

(Continued on page 6)

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# White Flour in the U.S.A.—

## Enriched* with Vitamins and Iron for Better Nutrition

*by* Science Writer

*This article is one of a series devoted to the enrichment of family white flour, white bread and rolls, corn meal and grits, macaroni products and white rice.*

The enrichment of family white flour with thiamine, riboflavin, niacin and iron by American millers is a major success. It has made great contributions to better health in the United States by improving a staple food.

Since the start of the program in 1941 by millers, voluntarily, the evidence is conclusive that enrichment not only has reduced the number of cases of certain dietary diseases but also is promoting the mental and physical vigor and well-being of the U. S. population generally. Because of its demonstrated value, the principle and practice of enrichment have been applied to other foods made from grains: corn meal and grits, white rice, macaroni, spaghetti, noodles, pastina, farina—and, of course, to white bread and rolls.

Doctors and diet experts have long supported white flour enrichment. The Council on Foods and Nutrition of the American Medical Association and the Food and Nutrition Board of the National Research Council are on record as endorsing the practice.

The legislatures of a majority of the States plus Hawaii and Puerto Rico have enacted laws which make mandatory the enrichment of all family white flour, as well as white bread, sold commercially in those areas.

American homemakers, too, favor foods they know to be enriched—a fact demonstrated by surveys. They look for these words on package labels: "Enriched with vitamins and iron for better nutrition."

### What Is Enrichment?

It's an axiom in the milling industry that consumers want beautifully fine, white flour. When wheat is milled and processed to get the white flour which the public demands, vitamin and mineral values are unavoidably lost.

Enrichment restores to white flour the following important vitamin and mineral factors: thiamine, riboflavin, niacin and iron. Calcium also may be added as an optional ingredient. The process is simple and inexpensive. A mixture of the vitamins and iron is fed into the flour stream during processing. This insures that the enriching ingredients are spread evenly throughout the flour.

The U. S. Food and Drug Administration has established standards which white flour must meet to be properly labeled enriched. The requirements, in milligrams per pound, are:

| | *Min.* | *Max.* |
|---|---|---|
| **Thiamine** (vitamin $B_1$) | 2.0 | 2.5 |
| **Riboflavin** (vitamin $B_2$) | 1.2 | 1.5 |
| **Niacin** (another "B" vitamin) | 16.0 | 20.0 |
| **Iron** | 13.0 | 16.5 |

(In Canada, too, the same standards have been set for enriched white flour through the amendment of the Food and Drugs Act.)

### Vitamins Are Made

The science of chemistry is so advanced these days that many of Nature's complex substances can be "duplicated" in the laboratory. This has happened with many vitamins. First, the chemical composition is learned. Second, the pure substance is isolated. Third, a "duplicate" is made by synthesis. And fourth, the laboratory techniques are extended to large scale operation.

The manufactured "duplicate" is identical chemically and in biological activity with Nature's own product. A vitamin is still a vitamin regardless of its source. So efficient is large scale manufacturing that vitamins are sold at a lower cost than if they were extracted from natural sources.

The Hoffmann-La Roche people make top quality vitamins actually by the tons. To do this they use amazingly complex processes with scientific production controls and the latest equipment which fill buildings each a city block square and many stories high.

Reprints of this article, and all others in this series are available without charge. Please send your request to the Vitamin Division, Hoffmann-La Roche Inc., Nutley 10, New Jersey. In Canada: Hoffmann-La Roche Ltd., 286 St. Paul Street, West; Montreal, Quebec.

*The watermills are gone. Today's needs require today's methods. How sensible it is that millers across the nation restore health-giving vitamins and minerals through enrichment.*

*Webster's Merriam Collegiate Dictionary includes this definition of "enrich": "to improve (a food) in nutritive value by addition in processing of vitamins and minerals".

# FOOD TECHNOLOGY

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## ANNUAL MEETING BULLETIN BOARD

(Continued from page 2)

luncheon on Wednesday noon is to be at the Maramor. This is located in the center of the business district, so the rest of the afternoon is free for browsing, shopping, movies, sight-seeing, or what-you-will. The hostesses in the women's headquarters will have many suggestions for those who want to see more of Columbus or its environs.

# Regional Section News

## NEW YORK SECTION

**Cold Sterilization of Foods Still in the Future.** Recent research indicates that radiation sterilization of foods is not yet a practical reality. Obstacles to commercial utilization of this technique were outlined at the January 19 meeting of the New York Section of the Institute of Food Technologists by Mr. O. F. Ecklund of American Can Company.

One of the most important problems is flavor change in foods irradiated to produce sterility. Off-flavors were noted in meats, fish, shellfish, dairy products, fruit, vegetables, and preserves. Degree of off-flavor, which varies with the particular food, can be reduced but not eliminated by irradiating foods in the frozen state.

Another serious problem is destruction of enzymes which produce spoilage in foods and are commonly destroyed by heat processing. They can also be inactivated by irradiation, but the doses required are much greater than those needed only to sterilize foods. Thus, destruction of enzymes by this technique greatly increases the problem of off-flavor and cost as well.

If products such as fruit, vegetables, and fish must be cooked to destroy enzymes, radiation sterilization offers little advantage over conventional methods of preservation. With meats, however, the enzyme problem is not as serious; and it is here that the new technique seems to show most promise.

Still to be overcome are adverse changes in texture and color produced by irradiation. And many irradiated foods deteriorate considerably in storage.

**Atomic Irradiation Alters Packaging Materials.** Atomic irradiation improves the properties of plastic materials for some applications. But the cost is high, and is likely to remain so for the next few years, in the opinion of Dr. E. J. Henley, Department of Chemical Engineering, Columbia University, and also a featured speaker before the New York Section of the Institute of Food Technologists on January 19. Dr. Henley explained that irradiation alters the molecular structure of plastics by shifting the electronic forces between atoms. And this change affects the melting point, strength, and elasticity.

Irradiated polyethylene shows the greatest improvement with low alpha, gamma, or beta ray irradiation doses. Its strength is increased at temperatures above 100° C., indicating possible application as a flexible container that will withstand heat treatment of foods.

Other possible applications for irradiated plastics are in plastic piping, lining for metal containers, and electrical insulation.

Dr. Henley mentioned that the irradiation of one type of beverage bottle turned it into an opaque, black container.

## PHILADELPHIA SECTION

The Philadelphia Section met December 7th at Drexel Institute. Almost a hundred members and guests were present to celebrate our annual Ladies' Night. Every person present at the dinner received a large collection of gifts, donated by various local food industries.

The guest speaker was Mr. A. A. Schaal, Director of the Good Housekeeping Bureau, who spoke on "Food Trends and Consumer Protection." Mr. Schaal discussed the work of the Good Housekeeping Bureau in investigating and testing advertised food products for safety, accuracy of labeling and fulfillment of purpose.

Among the food trends noted were the tremendous expansion in the production and sale of prepared baking mixes, and the phenomenal increase in the variety of frozen foods available to the public. Dehydrated and partially dehydrated foods were discussed, and the various types and uses of dietary foods were described. A question and answer period concluded the meeting.

At the February 1st meeting Dr. John H. Nair, Assistant Director of Research, Thos. J. Lipton Co. Inc., Hoboken, N. J., is scheduled to speak. His topic is "Guides to Consumer Preferences in Food."

## NORTHERN CALIFORNIA SECTION

**Report of the Secretary—1954.** During 1954 the number of National members of the Institute of Food Technologists in the Northern California Section area passed the 400 mark. An official check of the membership cards was made by Headquarters in August, and on December 31 the records show 411 members and 14 student members. A fourth Councilor will take office in January 1955.

Sixty new members joined the Section during the year and the membership of the Section at the end of the year is 505, including 17 students. At the Section Meeting June 10, the membership approved a new By-Law, establishing the William V. Cruess Scholarship. The National Convention in Los Angeles gave many of our members a welcome opportunity to participate in National activities. In October a new Sub-Section was established in Fresno.

There were five regular dinner meetings during the year, and one special meeting. A successful picnic was held at the Pink Horse Ranch, Los Altos, June 12. The year's activities ended with a well attended all-day meeting at the Western Utilization Branch of the U. S. Department of Agriculture, followed by dinner.

February 11
Chinese banquet, arranged and described by the speaker, Mr. C. A. Rietz, President of Rietz Manufacturing Company

April 8
"Food Technology in the United States"
Dr. Emil Mrak, Chairman, Dept. Food Technology, University of California, Berkeley and Davis

June 10
"The Nation's Nutrition and the Food Technologist"
Dr. Agnes Fay Morgan, Chairman, Dept. Home Economics, University of California, Berkeley

(Continued on page 8)

## Best NEW Business?
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Stop the diet shopper with SUCARYL®

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# Molecular distillation and the cost of emulsifying margarine

You'll have to look quite a while in the supermarkets these days to find a margarine that denies itself the advantages of a monoglyceride emulsifier. Some of them use a mixture of mono- and diglycerides. Others, being made by our customers, rely little on the relatively less effective diglycerides. These latter fellows, we maintain, have grasped a profitable subtlety.

Myverol® Distilled Monoglycerides cost somewhat more than the mono-di mixtures. This is inevitable because it takes an additional step to produce them. The additional step is our unique molecular distillation process. It takes the crude mono-di mixture and removes from it di- and triglycerides which contribute little to emulsification. As a result, our margarine-making customers get a lot more emulsification per pound of emulsifier—so much more that the saving on the amount of emulsifier required swallows up immediately the slight cost of the molecular distillation.

That is the point. The fact that the molecular distillation also removes the catalyst, the free fatty acid, and the glycerine from the emulsifier is a sort of bonus that gives the margarine maker a "cleaner" product.

How little Myverol is needed to make a margarine emulsion just tight enough to keep texture creamy, evaporation loss minimal, foaming low, and boiling calm? Our laboratories would like to co-operate with yours in answering that and other fat-emulsification questions. It might pay off handsomely to get in touch with *Distillation Products Industries,* Rochester 3, N. Y. Sales offices: New York, Chicago, and Memphis • W. M. Gillies and Company, Los Angeles, Portland, and San Francisco • Charles Albert Smith Limited, Montreal and Toronto.

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## REGIONAL SECTION NEWS

(Continued from page 6)

July 15
"Homemakers Reference Committee of the Kroger Foundation"
Dr. George F. Garnatz, Director of Kroger Foundation at Cincinnati

August 12
"Rheology"
Dr. Leonard Farber, Associate Professor of Mechanical Engineering, University of California, Berkeley

October 29
"Management and the Future of the Baby Food Industry"
Dan Gerber, President of Gerber Products Company

December 2
Annual Meeting program attached
Dinner speaker: Bernard Feinberg of the U. S. Army Quartermaster Corps, Oakland, spoke on "The Food Technologist and the Formicidae"

## SOUTHERN CALIFORNIA SECTION

The first meeting of the year was a glowing success in respect to attendance, food, speaker, and presentation. It was held at the Rodger Young Auditorium, Wednesday January 19, with Dr. Ernest Guenther, vice president and technical director of Fritzsche Bros. showing a color movie on "Essential Oil Production in Europe and North Africa." Dr. Guenther is an authority on the flavor and perfume oils.

**J. R. Lindquist (left) and the speaker, Dr. Ernest Guenther (right).**

Most of the essential oils contain 40 to 50 ingredients each, in yields varying from 16% of the treated material for oil of clove to 0.025% for attar of rose. Yearly production runs from 50 to 100 million dollars' worth; they are put into almost everything we use "from morning 'til night, from baby powder to embalming fluid," quoting Dr. Guenther. By far the greatest bulk of the essential oils is obtained by steam distillation, but those that require extreme care are obtained by simple squeezing or by extraction with volatile solvents followed by meticulous purification.

The best jasmine at $600/lb., is made in southern France, where "know-how" means to pick the flowers as they open early in the morning, to extract them within 2 to 3 hours after picking, and to remove the solvent under vacuum so as not to injure the hyper-sensitive aroma. Also from southern France comes the delicate lavender, growing wild in the highlands and recovered in portable stills; and lavendine, a hybrid, which tolerates a lower altitude and is cultivated. The first tech-

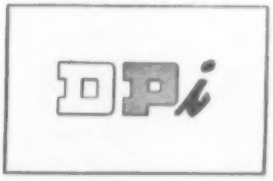
(Continued on page 10)

The price of vitamin A in bulk is now little more than one-quarter of what it was in 1948. This suggests new consideration of vitamin A enrichment decisions.

1948 was the year when, under the trade-mark "Myvax," the first man-made vitamin A became available on the American market in commercial quantity. For a current quotation on it in individual containers of Myvapack Vitamin A, each premeasured for one batch of an individual food product, write *Distillation Products Industries*, Rochester 3, N. Y. Sales offices: New York, Chicago, and Memphis • W. M. Gillies and Company, Los Angeles, Portland, and San Francisco • Charles Albert Smith Limited, Montreal and Toronto.

"Myvapack" is a trade-mark.

***leaders in research and production of vitamin A***




Also... vitamin E... distilled monoglycerides
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## REGIONAL SECTION NEWS

(Continued from page 8)

nological advance in decades is the Eysseric still in which the flower-laden retort is completely covered by the heating jacket, thus preventing reflux condensation, reducing the time from 45 to 15 min. per batch, improving quality and yield, and producing a bone-dry residue which is immediately used as fuel.

But the automobile, says Dr. Guenther, is bringing to the flower lands of France the same encroachment by residential subdivisions and industry as to the orange groves of California. Pursuing the parallel, land sells for $1000 an acre. Nearby north Africa provides cheaper land and labor, and consequently is blossoming a full-blown flower industry, especially in rose and geranium, with modern, centrally-located extraction plants to increase efficiency. But speaking of wonders, Dr. Guenther says that in the case of essential oils, the nose is still superior to all the infra-red, ultraviolet, physical and chemical tests combined.

## CHICAGO SECTION

Chicago Section's best attended meeting for 1954 was the recent Christmas Party, when about 150 crowded the private dining room in the Palmer House. Many members brought their wives who not only enjoyed the special beverages, meal, and program but went home with some of the door prizes.

After the barbequed chicken dinner, Section President, Stan Brockington introduced his wife who lead the traditional Christmas sing, harmonizing the low bass tones with the clear soprano voices.

Ray Morse introduced the speaker, Paul R. Leach, Jr., Midwest Manager of the Extension Division of E. I. du Pont de Nemours & Company. His talk, "An American Paradox," pointed out how industry has helped make our democratic country the greatest in the world. He urged the audience to correct the mistaken ideas that industry, whether big or small, is the "villain" of our social structure. The second part of the talk was devoted to new developments from the du Pont laboratories. His mention of mylar film, sponge hats, lamination of aluminum to film, promoted considerable discussion. He closed with the thought-provoking statement that only 1 out of 20 du Pont research projects ever pays off in a marketable product.

## GREAT LAKES SECTION

The Park Shelton Hotel, Detroit, Mich., was the scene of the Section's Winter Meeting—1955 and January 21 the date. The morning was devoted to a tour of the Goebel Brewing Company, corner of Gratiot Ave. and Rivard St., which was followed by a luncheon in the Circus Room and a talk by Mr. Howard Nassze, Chief Chemist.

Five papers constituted the Technical Program and were as follows:

"Technical Aspects of Commercial Frying"—By Dr. W. A. Quammen, Procter and Gamble Company, Cincinnati, Ohio.

"Sorbic Acid as a Preservative for Sweet Cucumber Pickles"—By Dr. Ralph W. Costilow, Michigan State College.

"Research in Red Cherry Processing"—By Dr. C. L. Bedford, Michigan State College.

"Food of the Gods"—By Benjamin P. Forbes, Forbes Chocolate Company, Cleveland, Ohio.

Dr. Sereck H. Fox, Vice President, Pharmaceutical Research and Control, Gelatin Products Division, R. P. Scherer Corp., Detroit, was the evening dinner speaker. He spoke on "A Predicament in Science."

## MARYLAND SECTION

At the January 14th meeting of the Maryland Section, Institute of Food Technologists, at the Hotel Stafford in Baltimore, there were thirty-seven members and guests in attendance. Mr. Don Truax spoke on the importance of package consumer appeal. He supplemented his talk with a clever film and a display of artistic samples.

In the movie film a hidden camera revealed the care with which most buyers choose their frozen foods. An interviewer on the spot determined that they were influenced by attractive complete packaging, clear printing and precise instructions. Mr. Truax's samples were used to show how artistic and durable today's packages are compared with those of prewar packages. During his talk, he elaborated on his film, "Time for Shopping," and stated that in olden days a symbol only on the packaged goods identified it by brand. Now the package and its design must:

1) Sell the buyer (no clerk picks it up for him);
2) Identify the product on the shelf with advertising;
3) State the condition and methods of use of the product.

Mr. Truax predicted the multiple packaging of units, frozen cut-up poultry packaging in plant, and improvement in synthetic coatings of papers.

The question-and-answer period was as interesting as the talk and showed the Food Technologist's realization of his part in proper packaging.

## PHI TAU SIGMA

The National Council of Phi Tau Sigma, recently founded Food Science Honor Society, has approved a petition submitted by its members at the Massachusetts Institute of Technology requesting a charter for a chapter of the society to be established there. Massachusetts Institute of Technology thus becomes the second institution to have a Phi Tau Sigma chapter on its campus. Members at the University of Massachusetts in Amherst, where the Society was founded in 1953, were the first to petition for a chapter charter which was granted early last year.

The National Council of the Society, whose membership has grown to approximately two hundred and fifty within a little over a year, also disclosed that expressions of interest in additional chapters had been received from members at several other institutions.

Signing the petition for establishment of the chapter at the Massachusetts Institute of Technology were the following members of Phi Tau Sigma: Samuel C. Pres-

(Continued on page 14)

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## REGIONAL SECTION NEWS

(Continued from page 10)

cott, Bernard E. Proctor, Cecil G. Dunn, Samuel G. Goldblith, Ernest E. Lockhart and Henry Sherman.

### ST. LOUIS SECTION

A Food Technology Short Course is to be given by the University of Missouri College of Agriculture on March 18 and 19 in cooperation with the Institute of Food Technologists, St. Louis Section. The program will be devoted to *Food Additives* and the schedule is as follows:

**FRIDAY, MARCH 18, 1955**

8:30-9:30 A.M. Registration—Memorial Student Union

9:30 A.M. Panel Discussion: "Problems and Purposes of Food Additives"
Moderator: Dr. Kenneth G. Weckel, University of Wisconsin
Dr. C. E. Gross, John Morrell & Co.
Mr. E. M. Deck, Mrs. Tucker's Foods
Dr. W. B. Bradley, American Institute of Baking
Mr. C. L. Smith, Continental Can Co.

1:45 P.M. Tour of Food Technology and Nutrition Laboratories, College of Agriculture

4:00-5:30 P.M. Social Hour, Daniel Boone Hotel

7:00 P.M. Banquet—Memorial Student Union
Dr. E. M. Nelson, Food & Drug Administration, Department of Health, Education on Welfare, "Legal Aspects of Food Additives"

**SATURDAY, MARCH 19, 1955**

8:30-9:30 A.M. Registration—Memorial Student Union

9:30 A.M. Panel Discussion: "Technology of Food Additives"
Moderator: Dr. H. K. Muer, General Foods Corp.
Mr. M. R. Johnston, University of Missouri
Mr. R. L. Henrickson, University of Missouri
(Two industry members not confirmed)

12:15 P.M. Luncheon—Memorial Student Union

1:30 P.M. Panel Discussion: "Nutritional Aspects of Food Additives"
Moderator: Dr. I. J. Hutchings, H. J. Heinz Co.
Dr. H. E. O. Heineman, Pet Milk Co.
Dr. Paul Logue, Monsanto Chemical Co.
Dr. G. K. Parman, Hoffman LaRoche, Inc.
Dr. B. L. O'Dell, University of Missouri

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## PERSONNEL

Dr. L. E. Clifcorn, Director, Fundamental Research Division, Continental Can Co., was recently elected Vice President of the Agricultural Research Institute.

Dr. Lawrence Rosner of the Laboratory of Vitamin Technology, Inc., Chicago, has been reelected Chairman of the Animal Nutrition Research Council.

Dr. William McKinley Martin, well known in the food industry for his contributions in the aseptic canning field, has resigned his position as Director of Research with the Rheem Manufacturing Company to join G. F. Heublein & Bros., Inc., as Executive Vice President and Director of Andersen's Foods, Inc., their subsidiary at Santa Barbara, California.

The Societa Generale delle Conserve Alimentari Cirio, Naples, Italy, has invited Mr. Edward F. Kohman, Consultant, to spend six months at their canning plant, the largest in Italy, studying their products. The company manufactures baby foods in addition to other products.

# Selected Abstracts*

## ANALYTICAL METHODS

**Separation of iron from other cations by ion exchange on alginic acid.**

Specker, H., and Hartkamp, H. *Naturwissenschaften, 40,* 410-11 (1953).

Alginic acid (polymannuronic acid) will retain $Fe^{+++}$ from mixts. with other ions like $Cu^{++}$, $Mg^{++}$, $Ni^{++}$, $Al^{+++}$, and $UO_2^{++}$ almost quantitatively; the eluate (HCl, $H_2SO_4$, and AcOH) contains only traces of Fe. A column ht. of 30 cm. was used, diam 0.8 cm., 3-3.5 g. dry acid of screen size Din 20. Fe is also quantitatively removed from sulfate solns. prior to gravimetric assay.

## BIOLOGICAL SCIENCES

### BIOCHEMISTRY

**Studies on the origin of pectinolytic and cellulolytic enzymes in commercial cucumber fermentations.**

Etchells, J. L., Bell, T. A., and Jones, I. D. Paper presented at Institute of Food Technologists Annual Meeting, Los Angeles, 1954.

Previous work has demonstrated that brines from stock undergoing softening-type spoilage contain considerable activity of a pectinolytic enzyme similar in behavior to polygalacturonase. The development of control procedures to avoid or minimize softening of brined cucumbers depends, to a large extent, on knowledge of the origin of the softening enzymes in curing brines. The results of the investigations appear to implicate molds (higher fungi) as a potent source of the softening enzymes in brines. Further, it now appears that the actual mode of enzyme introduction into the brine is chiefly by way of the partially dried, heavily mold-laden, cucumber flowers that remain attached to the cucumber fruit. For example, brine samples from vats filled with small cucumbers that had a high percentage of flowers, either retained by the cucumber or added experimentally, were shown to contain high enzyme activity and, in general, the salt-stock was either soft or inferior in firmness. However, when the retained flowers were removed by hand and the cucumbers thoroughly washed, the brine samples were very low in enzyme activity and the cured stock was exceptionally firm. Also, firm stock was obtained from brining procedures designed to reduce the softening enzyme content by draining off the original brine after 36 hrs. and replacing it with new brine. The addn. of flowers or washing of the cucumbers did not influence the lactic acid fermentation as judged by development of acidity and drop in brine pH. Addnl. support for the view that softening enzymes in brines are usually of mold origin has been obtained from investigations on the populations, identity, and certain biochem. properties of the predominating molds occurring on the growing cucumber plant. Identification studies to date have revealed species belonging to about 40 different genera and families of molds. The 10 most frequently obtained were:

* These Selected Abstracts are made available to Food Technology through the cooperation of Associate Editor H. A. Campbell and the General Foods Corporation of New York, N. Y. The abbreviations found in these abstracts are similar to those used by Chemical Abstracts.

(Continued on page 16)

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## SELECTED ABSTRACTS

(Continued from page 14)

*Fusarium*, 264 isolates; *Penicillium*, 228; *Phomaceae*, 166; *Cladosporium*, 104; *Alternaria*, 87; *Dematiaceae*, 28; *Mucor*, 21; *Trichoderma*, 17; *Myrothecium*, 15; and *Aspergillus*, 14. These fungi represented 92 percent of the total isolations and practically all of the representative cultures tested have the ability to destroy pectin in cultural media. Also, the predominating genera obtained contain species with previous known history for the production of the cellulose-decomposing-enzyme, cellulase.

**The terminal free carboxyl groups of pepsin.**

WILLIAMSON, M. B., AND PASSMANN, J. M. *Biochim. et Biophys. Acta, 15*, 246-50 (1954).

The application of 3 methods to the detn. of the terminal free carboxyl groups in pepsin is described. It was detd. that pepsin has 2 terminal free carboxyl groups both of which are alanine.

**The liberation of aspartic acid during the acid hydrolysis of proteins.**

BLACKBURN, S., AND LEE, G. R. *Biochem. J., 58*, 227-31 (1954).

Aspartic acid is preferentially liberated during hydrolysis of proteins with hot dil. acids but not with concd. HCl at 37°. The specificity of the reaction and its mechanism are discussed.

### NUTRITION

**Effect of dietary amino acid balance on fat deposition in the livers of rats fed low protein diets.**

WINJE, M. E., HARPER, A. E., BENTON, D. A., BOLDT, R. E., AND ELVEHJEM, C. A. *J. Nutrition, 54*, 155-66 (1954).

Fat which accumulates in the livers of rats fed low protein diets contg. pork, beef, or egg albumin is reduced when the level of the dietary protein is increased. Supplementation of these diets with gelatin or fibrin or with threonine and glycine lowered the amt. of liver fat. Lysine in the presence of addnl. histidine and threonine further decreased the amt. of fat in the livers of rats fed low protein diets contg. egg albumin. Excessive deposition of liver fat was not observed when low protein diets contg. fibrin were fed. It is suggested that the maintenance of normal fat deposition in the livers of rats fed low protein diets contg. choline depends upon the presence of a specific ratio of amino acids in the diets.

**Protein metabolism in the pregnant rat.**

BEATON, G. H., BEARE, J., RYU, M. H., AND MCHENRY, E. W. *J. Nutrition, 54*, 291-304 (1954).

During the first 2 wks. of pregnancy in the rat, marked storage of fat and $H_2O$ occurs in the maternal carcass while there is little fetal growth. At about the 15th day of gestation, a definite decrease in fat stores occurs and the retention of protein increases. Accompanying protein retention there are decreases in blood amino N, in hepatic alanine-glutamic transaminase and in the rate of urea formation in liver slices.

**Protein supplementation. Relative nutritive values of proteins in whole wheat and whole rye and effect of amino acid supplements.**

SURE, B. *J. Agr. Food Chem., 2*, 1108-10 (1954).

Whole rye flour was superior in the nutritive value of its proteins to whole wheat flour. Amino acid supplementation of whole wheat flour gave markedly increased growth responses over those obtained with amino acid-supplemented whole rye flour.

**Cereals in nutrition. Nutritive value of rice germ.**

KIK, M. C. *J. Agr. Food Chem., 2*, 1179-81 (1954).

Data are given on the protein efficiency of rice germ in comparison with milled rice, the value of the proteins of rice germ supplementing those of milled rice, and the amino acid, vitamin, and mineral content of rice germ.

**Improving the nutritive value of flour. VI. A comparison of the use of soya flour and wheat germ.**

WESTERMAN, B. D., OLIVER, B., AND MAY, A. *J. Nutrition, 54*, 225-36 (1954).

Results indicated that both were significantly beneficial in promoting growth in rats when added to non-enriched flour but neither supported as good growth as the stock diet. When added to enriched flour these materials supported as good growth as the stock diet. No significant differences were found in rats receiving enriched flour plus wheat germ as against those receiving enriched flour plus soya flour in either the first or second generation. Soya flour when added to non-enriched flour seemed to aid in promoting better growth in the second generation than did wheat germ.

**Dental caries in the albino rat on high sucrose diets containing different amounts of aluminum.**

WYNN, W., AND HALDI, J. *J. Nutrition, 54*, 285-90 (1954).

These expts. were undertaken to det. whether Al, like F, when added to the diet in small amts. may offer some protection against dental caries. No significant differences were found in the no. of carious molars or in the caries scores as a result of the addn. of Al in the amts. used in this study, either in non-desalivated or desalivated animals. The addn. of Al up to 20 p.p.m. had no effect on appetite or growth of the animals.

**Effects of dietary calcium and phosphorus levels upon the physiological behavior of calcium and phosphorus in the rat.**

HANSARD, S. L., AND PLUMLEE, M. P. *J. Nutrition, 54*, 17-31 (1954).

With the use of radiochem. procedures the behavior of labeled Ca and P was studied as a function of the dietary levels of these elements.

**The retention of calcium from gypsum and phytin by the albino rat in relation to life span. Part I.**

BHARUCHA, R. P., AND MCCAY, C. M. *J. Gerontol., 9*, 439-45 (1954).

The Ca of gypsum was more available than that of Ca phytate as observed both in balance studies and in investigations on bone calcification. Those animals given higher amts. of Ca tended to go into neg. balance earlier than those receiving less Ca.

**Sodium-restricted diets.**

COUNCIL ON FOODS AND NUTRITION. *J. Am. Med. Assoc., 156*, 1081-3 (1954).

A very good review including: an explanation of terms and a discussion of the normal physiology of Na metabolism.

**The effect of fat level of the diet on general nutrition. XII. The requirement of essential fatty acids for pregnancy and lactation.**

DEUEL, H. J., MARTIN, C. R., AND ALFIN-SLATER, R. B. *J. Nutrition, 54*, 193-9 (1954).

Dietary fat is not required by the female rat for conception or for the completion of pregnancy when the diets are otherwise complete. Fat is required in the diet of the mother to insure the survival of the pups after birth. The constituents of the fat responsible for the survival of the young and for satisfactory lactation appear to be the essential fatty acids.

**The effect of fat level of the diet on general nutrition. XIII. The effect of increasing dosages of x-irradiation on the protective action of fat on radiation injury.**

CHENG, A. L. S., ALFIN-SLATER, R. B., AND DEUEL, H. J. *J. Nutrition, 54*, 201-7 (1954).

The present tests confirmed the earlier expts. in demonstrating the protective effects of dietary fat against x-irradiation in a variety of doses and given at several time intervals.

**The effect of water restriction on the food intake and food efficiency of growing rats.**

CRAMPTON, E. W., AND LLOYD, L. E. *J. Nutrition, 54*, 221-24 (1954).

The immediate effect of restricting the $H_2O$ intake of growing rats was to reduce substantially the voluntary intake of food and consequently to inhibit gain in body wt.

**Food faddism and public health.**

SEBRELL, W. H. *Federation Proc., 13*, 780-4 (1954).

Most food fads may be classified as manifestations of pleasure seeking, fears relative to food, exaggeration of food virtues, or doubts of a food's value. Misinformation is usually a factor, and this often stems from the mercenary efforts of food quacks.

(Continued on page 18)

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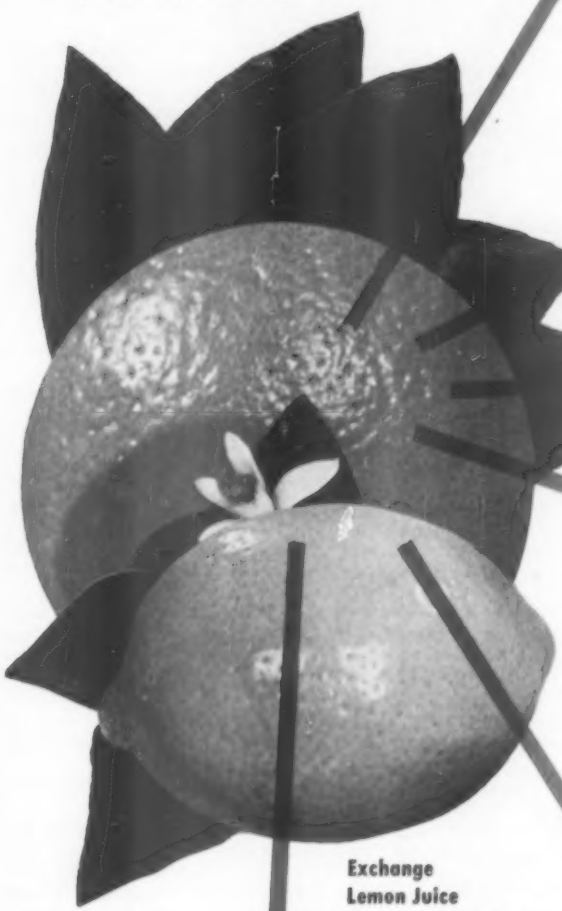

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## SELECTED ABSTRACTS

(Continued from page 16)

**Control of nutrition claims under the food, drug and cosmetic act.**

NELSON, E. M. *Federation Proc., 13,* 790-3 (1954).

A brief description of the operation of the F.D.A. discussing purpose of the group and some difficulties it encounters.

### PHYSIOLOGY AND MEDICINE

**Organ weights and obesity in mice.**

WAXLER, S. H., AND ENGER, M. *J. Nutrition, 54,* 209-14 (1954).

The organs of obese animals tend to be heavier than those of control mice, and this increase in wt. is apparent in the wet, dry and defatted state. This increase in organ wt. of obese animals cannot be accounted for by adipose tissue alone. Mice which were made experimentally obese were subsequently reduced to the wt. of controls. The organ wts. of these reduced animals were of the same order of magnitude as those of the controls.

**Obesity.**

WALKER, H. C. *Arch. Internal. Med., 93,* 951-66 (1954); *Metabolism, Clin. and Exptl., 3,* 562 (1954).

This is a good review article on obesity, its complications and its sequelae. It summarizes the current concepts of the etiology, both endocrine and nonendocrine, and points out the life insurance statistics previously obtained by Dublin regarding the higher incidence of degenerative diseases in obese patients.

**Obesity. A brief review of the problem.**

BERRYMAN, G. H. *Metabolism, Clin. and Exptl., 3,* 544-60 (1954).

An attempt is made to collect some of the voluminous literature into an organized form. 68 references.

**Coffee breaks don't cause ulcers, medical authorities state opinion.**

*Tea & Coffee Trade J., 107,* 25-6, October, 1954.

Expts. eliminate caffeine as responsible for peptic ulcer, it may even be considered a possible remedy.

**The physiologic effects of coffee and coffee extracts.**

FLEISCH, A., AND WENNER, V. *Schweiz. med. Wochschr, 84,* 223-30 (1954).

The effects of filtered coffee, sol. coffee exts., and coffee ext. freed of caffeine were tested. The lowered pulse rate in all 3 series is related to the 2 hrs. of rest imposed on all subjects prior to the test. The tactile sensitivity was increased in all subjects by the 3 materials. The ext. free of caffeine does not influence tremor or blood pressure, whereas the caffeine contg. prepns. increased both. The effects are identical with those of pure caffeine. Expts. on mice showed that about ⅔ of the toxicity of coffee exts. are due to the caffeine and ⅓ to other substances. The toxicity of the sol. ext. was only about 69% of that of the filtered coffee.

**The effect of high levels of terramycin and streptomycin on longevity in the rat.**

FRENCH, C. E., URAM, J. A., INGRAM, R. H., AND SWIFT, R. W. *J. Nutrition, 54,* 75-80 (1954).

In an attempt to minimize the chronic pneumonia commonly observed in aged rats by the continual administration of streptomycin and terramycin incorporated in the diet at high levels (0.02 and 0.04%) beginning at the age of 11 mos., the av. life span of albino rats of both sexes was decreased about 10%.

**Hepatic tumors in rats following prolonged ingestion of milk and egg yolk.**

NELSON, N., SZANTO, P. B., WILLHEIM, R., AND IVY, A. C. *Cancer Research, 14,* 441-4 (1954); *J. Am. Med. Assoc., 156,* 913 (1954).

Ten male and 10 female albino rats were placed on a diet designed to produce arteriosclerosis. The diet consisted of 5% powd. egg yolk in whole milk. Tumors that appeared to be hepatomas developed in 3 male and in 3 female animals. No hepatic tumors occurred in a group of 25 animals of the same age receiving normal diets. A possible common factor involved in the genesis of the hepatic tumors in obese rats and in undernourished animals is an abnormality in bile metabolism. It seems more than likely that the high percentage of cholesterol in the milk and egg yolk diet might in time interfere with the normal metabolism of bile.

### ENGINEERING AND PLANT EQUIPMENT

**The use of compressed air in food processing. II.**

SLADE, F. H. *Food, 23,* 416-20 (1954).

The various methods available for removing impurities from compressed air in the pipe-line are reviewed in this article.

### FOOD AND FOOD TECHNOLOGY

#### CEREALS AND GRAINS

**Cereal storage effects. Deteriorative changes in the oil fraction of stored parboiled rice.**

HOUSTON, D. F., HUNTER, I. R., MCCOMB, E. A., AND KESTER, E. B. *J. Agr. Food Chem., 2,* 1185-90 (1954).

This report presents the changes in several characteristics of the oil fraction of parboiled rice over a range of storage conditions, and provides information useful for comparison with changes in the oil of rice containing active enzymes. The trends shown offer a basis for a possible accelerated test for storage life of moist heat-processed rices such as parboiled and quick-cooking rice.

#### FATS AND OILS

**The higher alkyl gallates.**

VAN SLUIS, K. J. H. *Food Manuf., 29,* 401-5 (1954).

The article discusses the use of the higher alkyl gallates as antioxidants in food.

#### FISH AND SEAFOOD

**Seaweed harvesting and processing research.**

*Food Manuf., 29,* 447-8 (1954).

Work on the development of continuous harvesting machinery and the extn. of alginates from seaweeds is reported.

**Fish flour.**

FOOD AND AGRICULTURAL ORGANIZATION. *Com. Fisheries Rev., 16,* 54, October, 1954.

Large-scale tests of the acceptability of flavorless fish flour as a protein supplement in child feeding will be conducted in 4 Latin American countries in the near future. If the tests show that fish flour is acceptable as a food supplement in these countries, the UNICEF administration may recommend an allocation of funds to establish a fish flour production plant in Latin America, which can utilize the area's abundant fish resources. At present very little fish flour is produced commercially for human consumption.

#### FRUIT AND VEGETABLES

**Fruit storage effects. Carbonyl compounds in apple storage volatiles.**

HENZE, R. E., BAKER, C. E., AND QUACKENBUSH, F. W. *J. Agr. Food Chem., 2,* 1118-20 (1954).

Carbonyl compds. were detd. in apple storage volatiles collected on activated C in a com. refrigerated apple storage. Acetaldehyde, acetone, and propionaldehyde were definitely identified. Fifteen other carboynl compds. were sepd. chromatographically as their 2,4-dinitrophenylhydrazone derivs., and their absorption spectra are presented.

**Flavor origin. Flavor and odor components in the tomato.**

SPENCER, M. S. *J. Agr. Food Chem., 2,* 1113-18 (1954).

Suitable methods for the isolation of tomato flavoring constituents were shown to be vacuum distn. at 20 mm., or solvent extn. followed by mol. distn. of the solvent ext. Three different types of tomato odor fraction were isolated chromatographically from the concentrates.

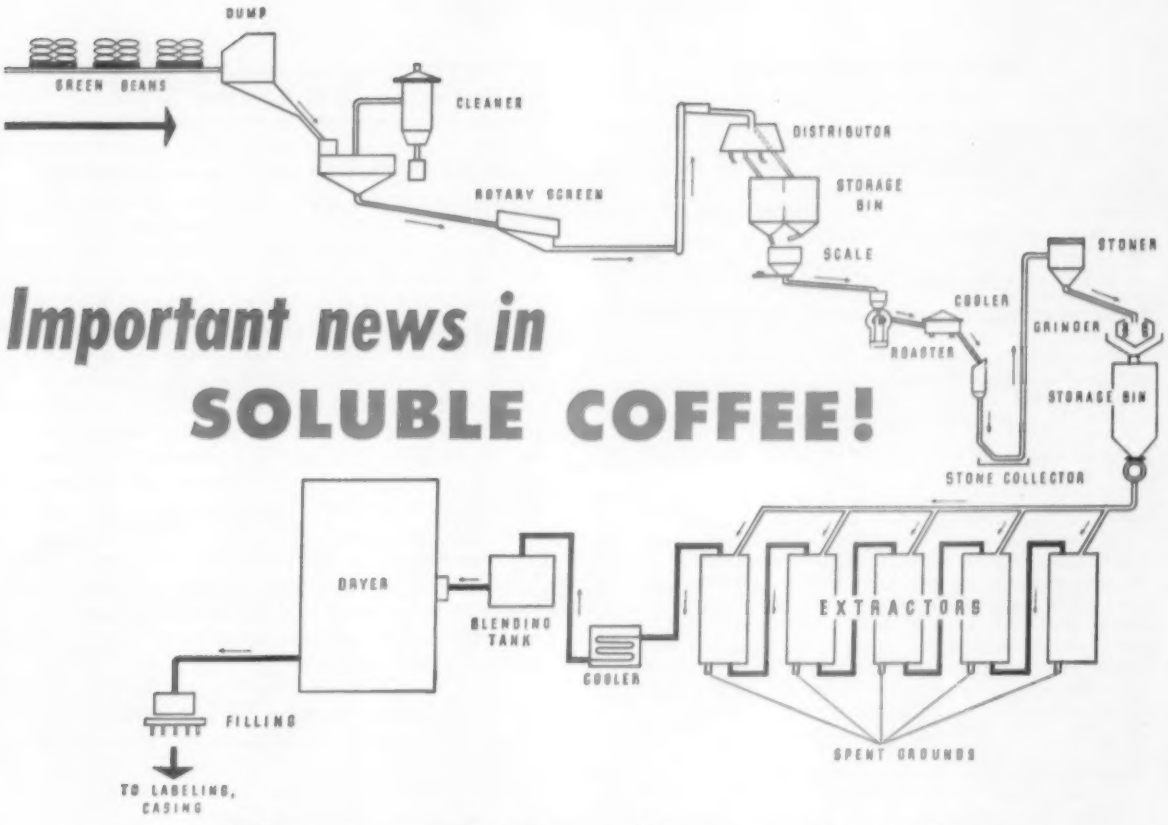
#### GELATIN

**The titration curve of gelatin.**

KENCHINGTON, A. W., AND WARD, A. G. *Biochem. J., 58,* 202-7 (1954).

A rapid method of detg. the titration curve of gelatins is described and the accuracy indicated. Revised criteria for the

(Continued on page 20)

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## SELECTED ABSTRACTS

(Continued from page 18)

interpretation of the titration curve are presented. The anomalous values for the histidine content of gelatin by titration curve analysis are brought into agreement with those from other methods. The whole of the analytical data obtainable by use of the titration curve and isoelec. pt. are shown to be in agreement with those from chromatographic analysis.

### ORGANIC CHEMISTRY

**Qualitative analysis of organic compounds by mass spectrometry.**

BEYNON, J. H. *Nature, 174,* 735-7 (1954).

A review on the use of the mass spectrometer for the qual. analysis of unknown org. substances.

### PHYSICAL RESEARCH

**Infrared studies on solutions of polymeric electrolytes. II. Proteins.**

EHRLICH, G., AND SUTHERLAND, G. B. B. M. *J. Am. Chem. Soc., 76,* 5268-72 (1954).

Two proteins were investigated, bovine plasma albumin and β-lactoglobulin. Both were shown to contain $COO^-$ groups, which in acid soln. could be converted into COOD groups, thus providing direct evidence for the existence of these proteins as dipolar ions at the isoionic point. The absorption band which best characterizes the $COO^-$ group lies at 6.4 μ, very close to a peptide band at 6.45 μ. The latter, however, is shifted to 6.8 μ when the protein is deuterated, thus revealing the carboxylate group band.

### SANITATION

**Sampling instruments for air pollution surveys.**

SILVERMAN, L. *Public Health Repts., 69,* 914-23 (1954).

Thirty types of instruments are tabulated for comparison by methods which include: sedimentation, visual or photometric absorption, inertial and centrifugal force, impingement, filtration, washing or scrubbing, pptn., adsorption and condensation.

### MISCELLANEOUS INFORMATION

**Technology in the fine chemicals industry. 3. Process involving special hazards.**

DEWING, T. *Mfg. Chemist, 25,* 423-7 (1954).

Although the hazards of various processes may differ in degree, they all have certain features in common, so that some quite general safety principles can be applied to all potentially dangerous processes. After considering these general principles, the author discussed specific hazards, e.g., the use of Na and Li, Grignard reactions, methylations, nitrations and sulfonations, the use of toxic gases and of extremely poisonous substances. Safe manufg. technics, including plant design, are described.

**Problems and opportunities in the institutional field.**

JAEGER, H. H. *Canning Trade, 97,* 9-11+, November 22, 1954.

A market review pointing up the potential of this relatively unexploited field.

## Books

THE WHITE MAN'S DILEMMA. FOOD AND THE FUTURE. By John Boyd Orr. British Book Center, Inc., New York, N. Y. Price, $2.25.

If the white man uses his technical and industrial superiority in a military defense of his centuries-old prestige, he might well contrive the fall of Western civilization. If he uses his technological and economic resources to help the non-Western nations put an end to hunger and poverty, he risks the loss of that prestige in the levelling process that would ultimately bring world-wide equality. These are the horns of the white man's dilemma, which is to say the dilemma of the Western Powers, as Lord Boyd Orr sees it. With force and conviction the author presents a way out of the dilemma—the assumption by the Western Powers of the leadership of the human family in a peaceful march to a new age of prosperity and common brotherhood.

The foregoing highly simplified interpretation of Lord Boyd Orr's thesis is by no means an interpretation of the essential contribution of this provocative essay. The real value of the book, in this reviewer's opinion, is its contribution to the outlines of a world food policy. Fully aware of the difficulties to be surmounted before the world food supply can be increased to a point adequate to the demands of the world's population, the author has faith in the respective abilities of the engineer, the agricultural scientist, and the chemist to meet the challenge. The author epitomizes an immense amount of economic, social, scientific, and technological data, to document this optimism. This is not, however, a bookish optimism. The author's broad experience as Director General of the Food and Agriculture Organization of the United Nations appears to have enforced rather than weakened his faith in the ultimate triumph of modern science and technology over world population increases—and hunger and poverty.

In the final analysis, however—as the author points out—the difficulty in establishing a world food policy lies in the inability of nations to set aside national interests and to get together. Attempts to solve the world food problem by world organizations, such as the League of Nations and the United Nations, came close to success. Such "near misses," however, in the realm of world political science are not too reassuring. It would appear, on the basis of Lord Boyd Orr's essay, that here is one modern science that has lagged behind rather than led modern human needs. M. S. P.

## FUTURE MEETINGS FOR FOOD TECHNOLOGISTS

| 1955 | |
|---|---|
| March 7-10 | American Society of Bakery Engineers, Edgewater Beach Hotel, Chicago, Illinois |
| March 8, 9 | Third Annual Dairy Engineering Conference, Michigan State College, East Lansing, Michigan |
| March 13-17 | Frozen Food Industry Convention, Hotel Hilton, Chicago, Illinois |
| March 13-17 | National Association of Frozen Food Packers, Hotel Hilton, Chicago, Illinois |
| March 14 | Research Forum on Frozen Foods, Hotel Hilton, Chicago |
| **March 18-19** | **Third Annual Food Technology Short Course, Memorial Student Union, University of Missouri, Columbia, Missouri** |
| March 29-30 | National Conference of Interstate Milk Shipments, Hotel Peabody, Memphis, Tennessee |
| March 29-April 7 | The 127th National Meeting of the American Chemical Society, Cincinnati, Ohio |
| May 15-19 | Annual Meeting of the Association of Cereal Chemists, Chase Hotel, St. Louis, Missouri |
| May 22-26 | International Bread Congress, Hamburg, Germany. |
| June 8-11 | Annual Meeting of the Research and Development Associates, Chicago, Illinois |
| **June 12-16** | **Institute of Food Technologists, Deshler-Hilton Hotel, Columbus, Ohio** |

(Information concerning future dates of national and international meetings, conventions and exhibits of interest to food technologists should be sent to the editorial office.)

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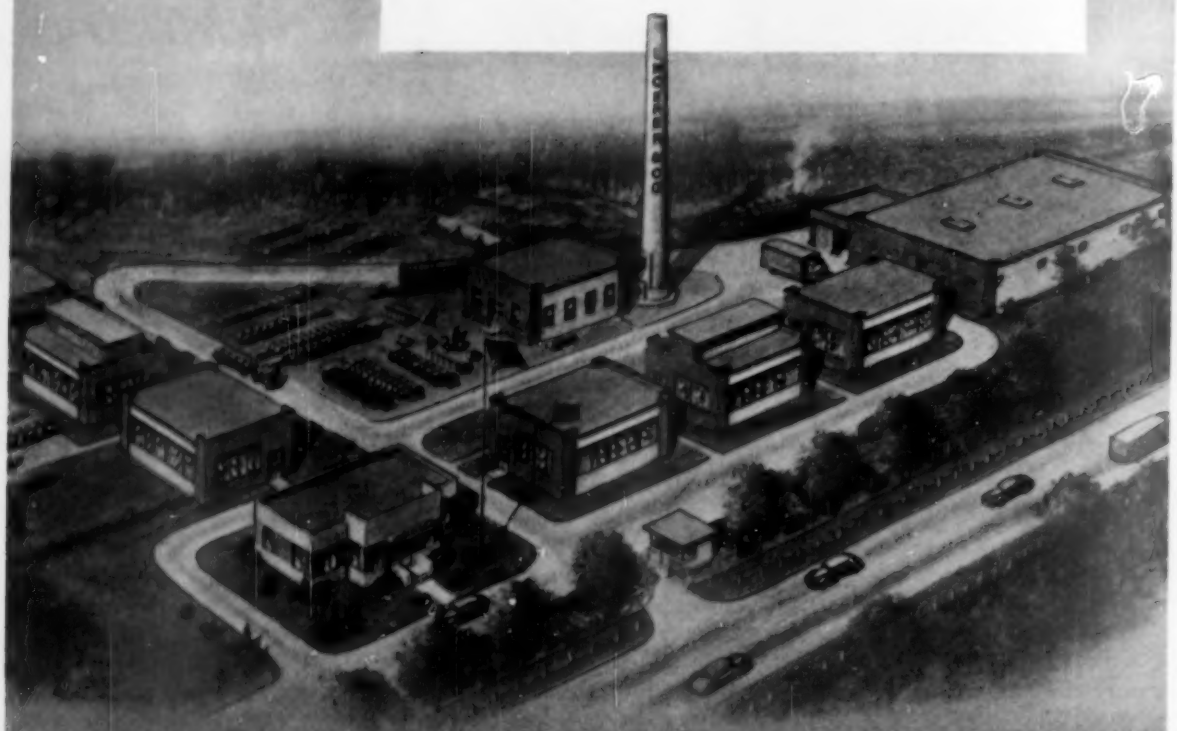


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# Factors Affecting Character Grade of Frozen Strawberries

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(Manuscript received July 19, 1954)

**Samples of frozen sliced strawberries from raw materials of known maturity were taken from the lines of freezing plants utilizing the common types of processing equipment for incorporating sugar or sirup with the sliced fruit. These samples were graded and analyzed to ascertain the effects of maturity and type of processing equipment on character, color, and ratio of constancy of fill of fruit to packing medium.**

During the past 20 or 25 years several types of equipment have been developed for mixing the sweetening agent (usually dry sucrose but to some extent sugar sirup) with sliced strawberries prior to freezing. In most cases, these types are designed to add weighed amounts of dry sugar either batchwise or continuously and in the ratio of four parts of berries to one part of dry sugar. The fruit and sugar are then mixed for several minutes to release sufficient juice to dissolve the sugar and form a slurry that will flow by gravity to the filler.

Over the years the procedures and equipment used in packing frozen sliced strawberries (perhaps in combination with variations in firmness of the fruit) have resulted at times in an excessively high percentage of broken, mushy, or disintegrated slices which detract from appearance of the product. When the present standards for frozen strawberries were issued by the U. S. Production and Marketing Administration in 1949, this factor, defined as *character*, was considered and was assigned a value of 20 points in a total score of 100. According to the standards, *character* means texture and degree of disintegration or the degree of wholeness as evidenced by crushed or partial strawberries and mushy strawberries. "Mushy strawberries" are defined as being so soft that they are a pulpy mass. *Character* is important in determining grade under these standards, since it can result in a B or D grade even if the product is scored high on all other factors.

Since *character* is so important, cooperative work was undertaken with the U. S. Production and Marketing Administration to study the effect of maturity and processing procedures on the amount of mushy or broken slices in frozen strawberries.

## TYPES OF EQUIPMENT

Packing procedure is much the same in all plants, from the initial stages on through the slicing operation. Strawberries are picked without caps, hauled in field flats to the plant, and stacked on the loading platform or, in some instances, in refrigerated storage. The fruit is dumped from the flats into a washer (usually the shaker types), is carried over inspection belts, and is then cut into ¼- or ⅜-inch slices by properly spaced circular rotating knives. At this point either dry sugar or high-density sirup is mixed with the fruit. Several kinds of equipment are used at present for this operation.

In most plants, sliced berries and sugar are weighed batchwise into one end of a stainless-steel, U-shaped tank about 5 to 7 feet long and 3 feet wide. This tank is equipped with ribbon-type mixers that, as they slowly revolve, mix the sugar with the berries until the sugar is dissolved and slowly propel the slurry to the discharge end of the tank (Figure 1). A few plants use this type of equipment to mix high-density sirup with sliced berries.

A second type, used in a limited number of plants, employs a screw conveyor which turns slowly inside a cylindrical tube or U-shaped trough about 8 inches in

**Figure 1. Ribbon-type mixer used to proportion and mix sugar and sliced strawberries.**

diameter and several feet in length. The sliced berries and sugar are metered continuously into a hopper at the feed end of the conveyor. By the time they have been propelled through the mixing tube and discharged, the sugar is dissolved and intimately mixed with the slices. In the two types of equipment described above, the berries discharge by gravity into a filler, usually the piston type.

A third type, which has been used in a few plants, is employed only for packing sliced strawberries in sirup. It is actually a 2-stage filling operation. The berries go directly from the slicer to a high-speed rotary filler which measures volumetrically and delivers to the package the desired amount of fruit. The partially filled containers then go to a siruper which adds the required amount of high-density sirup. The containers are then sealed, placed on trucks, and frozen.

## EXPERIMENTAL PROCEDURE

Plants using the various types of equipment in Oregon, Washington, and California cooperated by processing the samples needed. In 1950 various lots were selected to represent the range of maturity of the berries being received on the day the samples were processed. Fruit from each of the lots was fed through the regular processing lines with sufficient time allowed for berries from the previous lot to be cleared from the mixing and filling equipment before any samples for the study were taken. The required samples from each lot, usually 12 to 16 packages, were removed at intervals of about 30 seconds from the regular processing lines after filling and sealing. These were then coded, placed on trucks, and sent through the freezing tunnels. The samples were then packed in dry ice and shipped to the Western Utilization Research Branch in Albany, California.

In 1951 samples were taken from the processing line without regard to maturity, for the most part. Thirteen lots from 3 plants and 13 from 7 plants were sampled in 1950 and 1951, respectively. Samples from each lot were analyzed for total acidity, total sugar, total solids, and soluble solids. It was thought that one or more of these analyses would provide a reliable index for determining constancy of the ratio of fruit to packing medium for the various types of equipment, since this is known to be a problem in packaging frozen strawberries in small containers. Several samples from each lot were graded by the U. S. Production and Marketing Administration. In scoring for character, the mushy and disintegrated tissue was separated from the intact slices and the actual percentage by weight of mushy fruit was determined.

## RESULTS

Results obtained by the Production and Marketing Administration in grading samples from the various lots of fruit for the years 1950 and 1951 are shown in Figures 2 and 3. Since only color and character are pertinent to this study, scores for absence of defects are not included.

In both years samples with the highest percentages of mushy berries were obtained from plants using the screw-type mixing equipment (Figure 2). In many samples the extent of mushing was so serious that they were graded B and, in one case, D, because of character. Actual percentages of mushy fruit ranged from 19 to 23 in 1950 and from 16 to 31 in 1951. In 1950 maturity seemed to have very little effect on character (Figure 3). In 1951 one lot of overmature fruit was appreciably higher in percentage of mushy fruit. In this lot only one sample out of four received a grade of A; character was the limiting factor in the other 3 cases. Twelve of 24 samples processed in this type of equipment were graded B or lower because of character.

The ribbon type of mixing equipment, which is most widely used, resulted in an intermediate amount of broken or mushy berries with dry sugar as the packing medium. Percentages of mushy berries packed with this equipment ranged from 10 to 14 in 1950 and from 10 to 22 in 1951 (Figure 2). Only one sample of 17 graded in the 2 years was scored down because of character. There seemed to be little correlation between maturity of fruit and character of packed product (Figure 3).

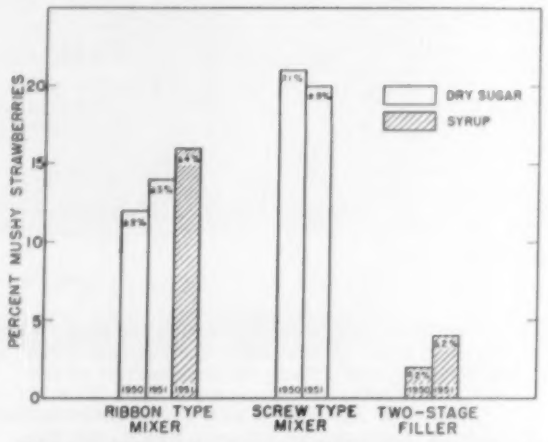


**Figure 2. Effect of mixing and filling procedures on percentage of mushy fruit in frozen sliced strawberries (1950 and 1951).**

Samples were also obtained in 1951 from one plant having ribbon-type mixing equipment and using sirup (3 + 1) for the packing medium rather than dry sugar. In this plant the sliced berries were automatically weighed into the ribbon-type mixer, sirup was metered in at the same point, and the product discharged into a piston-type filler. Character of product packed in the ribbon-type mixer was similar, whether the packing medium was dry sugar or sirup (Figure 2).

The lowest percentages of mushy berries were found in both 1950 and 1951 in samples packed with the 2-stage filling equipment (Figure 2). Here the percentage of mushy fruit ranged from 0.5 to 8% (average 2%) in 1950 and from 1 to 12% (average 4%) in 1951. Twenty-one of 29 samples received the maximum score of 20 points on character. Strawberries packed by this procedure contained only a small amount of "rag" or mushy fruit in the sirup. In these samples, the higher percentages of mushy fruit were associated with the riper fruit and almost invariably the firm fruit resulted in a product with a very small amount, 1% or less, of mushy berries.

The analytical data, particularly total solids and degrees Brix obtained in these experiments, are reasonably good indexes of constancy of ratio of fruit to packing medium. Since the fruit

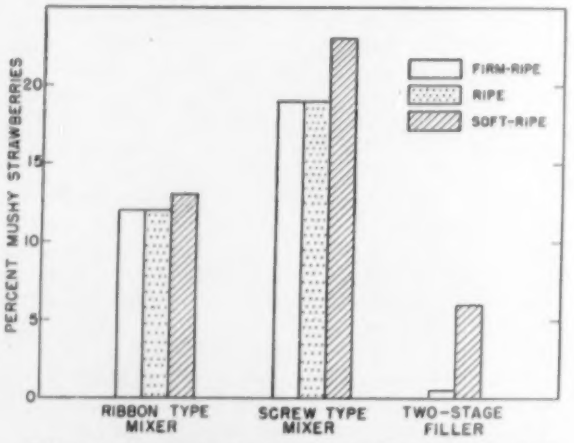


**Figure 3. Effect of maturity on percentage of mushy fruit in frozen sliced strawberries prepared in different types of mixing and filling equipment during the packing season of 1950.**

and packing medium have not come to equilibrium in composition at time of filling, variations in ratio of fruit to medium during filling of successive containers will cause corresponding changes in total solids, degrees Brix, and sugar and acid contents of the product. Data from these analyses showed significant differences in regard to constancy of ratio of fruit to sweetening or packing medium. However, these differences could not be clearly attributed to any one of the mixing devices included in the study. It was found that there were gross variations in the composition, particularly in sugar content, between various samples regardless of the type of equipment used. These ranged from 16.0° to 24.7° Brix and 21.1° to 32.3° Brix for the sirup- and dry-sugar packs, respectively. Variations in composition of raw material and processing variables together are the likely explanation for the variability in composition.

## DISCUSSION

Although these results make possible some rather definite conclusions on effect of equipment on character of product and, to a lesser extent, on constancy of ratio of fruit to packing medium, an overall evaluation of procedures cannot be made. Other factors such as color, labeling requirements, and general appearance (ratio of sliced fruit to sirup) of thawed product must be considered, especially in sirup packs.

Moreover, percentages of mushy berries in various samples result not only from the mixing operation but also to a certain extent from slicing and filling into containers. Within limits, these latter 2 factors can be disregarded as variables, since similar slicing equipment was used in all plants and, in all plants except the two using the 2-stage filling procedure, similar piston-type fillers were used. Thus, it is reasonably safe to ascribe differences in character to differences in procedures for mixing fruit with packing medium.

This study shows that plants using conventional ribbon-type mixing equipment should have little difficulty in meeting the limiting requirement for character for grade A frozen strawberries (which permits up to 20% of mushy berries) provided the equipment is in good operating condition. There was very little indication that maturity affects character of final product prepared in this equipment, but it may be that blending the riper berries with less mature fruit, as is done by many companies, aids in reducing the percentage of mushy berries. With this type of mixing equipment, substitution of sugar sirup for dry sugar does not seem to improve the character of the product appreciably.

From results with samples taken in one plant in 2 seasons and from a second plant in one season only, it seems that strawberries processed in the screw-type mixing equipment have a somewhat higher percentage of mushy berries than those processed in the conventional ribbon-type mixer. This moderate increase in mushy strawberry slices seems to be a very important factor in establishing grade. The results obtained have shown that with use of the ribbon-type mixer very few samples exceed the tolerance of 20% set up in standards for grade A sliced strawberries, although a fairly high percentage approaches this figure rather closely. Thus it is obvious that only a relatively small increase in amount of mushy berries, which may be brought about through use of the screw-type mixing equipment, can result in a substantial increase in the percentage of samples down-graded because of character.

From the standpoint of character, the samples packed by the 2-stage filling operation were much superior to those packed by the other 2 procedures. For the most part, juice from samples packed in this way was almost entirely free from "rag" or pulp and the cut surfaces of practically every slice were sharp and well defined.

If choice of equipment for mixing sliced strawberries with packing medium were based on character alone, results of this investigation definitely favor the 2-stage operation. As mentioned earlier, however, other factors must be considered. Color is one of the most important. Its importance is indicated by the fact that in the Production and Marketing Administration standards for frozen strawberries 40 points are assigned to color, only 20 to character. From the statements of many packers, there is a fairly widespread opinion that the color of sugar-packed strawberries (4 + 1) is superior to sirup-packed (3 + 1). Obviously there is less dilution of pigment if dry sugar is used, which should give a little more intense color to the dry-sugar pack. Comparison of color scores of the sirup and dry-sugar packs did not reveal any significant color differences. Perhaps this comparison is not justified, since variation among lots of raw material is much greater than the smaller color differences that may be expected as a result of differences in packing medium. However, it may be worth noting that, with the exception of samples from one plant in 1951, no difficulty was encountered in meeting the color requirements for grade A in any of the sirup-packed samples. This particular series was packed late in the season from rather dark-colored strawberries.

## SUMMARY

Three of the types of equipment commonly used by packers of frozen strawberries in mixing fruit with packing medium were included in this experiment to determine their effect on the character and constancy of ratio of fruit to packing medium. Types of mixing equipment studied included the common ribbon-type mixer, the screw-type mixer, and the two-stage filling operation by which sliced strawberries are filled into the container and sirup is added later in a separate operation.

Little difficulty was experienced by packers using the standard ribbon-type equipment in meeting the Production and Marketing Administration character requirements for Grade A frozen strawberries.

The two-stage filling procedure resulted in the lowest percentage of mushy slices (average 3%), the standard ribbon-type mixer was intermediate (average 13%), and the screw-type mixer gave the highest percentage of mushy berries (average 21%).

Substitution of sirup for dry sugar did not substantially reduce the percentage of mushy berries where ribbon-type mixers were used.

The three types of equipment seem to be similar in regard to constancy of ratio of fruit to packing medium filled into the containers.

Within the range of maturity of fruit normally processed, maturity did not substantially affect the percentage of mushy berries found in samples processed in standard ribbon-type mixers.

# Effect of Fruit Handling Methods on Juice Quality of Apples

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AND

ARCHIE VAN DOREN

*Tree Fruit Experiment Station, Wenatchee, Washington*[b]

(Manuscript received July 17, 1954)

**Post-harvest ripening was found to be the most important factor in the juice quality of Jonathan, Golden Delicious, and Winesap varieties. Ripening for at least one week was found necessary to avoid an undesirably sharp, astringent flavor in unblended juices, while ripening for 4 to 6 weeks resulted in poor flavor in some cases. Post-harvest ripening was accompanied by a decrease in firmness, a loss of starch and acid, and an increase in sugars. The advantage of post-harvest ripening to flavor was not apparent when juices were used in blends with fully-ripened standard Delicious. Use of unripened Jonathan and Winesap permitted the use of a considerably higher proportion of Delicious in preparing blends of uniform acid content without appreciable loss of flavor.**

The importance of proper ripeness of standard Delicious apples in the production of good-flavored juice was established in an earlier study *(3)*. The present report describes results of studies on the effect of harvest maturity, post-harvest ripening, and grade on the composition and quality of juices from apples of the Jonathan, Winesap, and Golden Delicious varieties. Because Jonathan and Winesap are used mainly in blends with standard or red Delicious, particular attention was given to the effect of fruit handling methods on the flavor of such blends.

## MATERIALS AND METHODS

**Selection of fruit.** Fruit for this study was harvested from the Tree Fruit Experiment Station orchards near Wenatchee, Washington, during 1952 and 1953. The Jonathan variety was harvested at 2 maturities each season. The first harvest, representing the maturity of commercial fruit harvested for the early fresh market, was segregated into a *fancy to extra-fancy* combination grade and C grade on the basis of color. C grade fruit had less than ⅛ solid red surface color in 1952 and less than ¼ solid red surface color in 1953. The C grade fruits from these first harvests represented Jonathans available to juice processors from fresh-fruit packing houses during the early "cider" season. The second Jonathan harvests were made at what was considered prime maturity for fresh market. The apples were handled as field-run grade, since practically all had attained a color of *fancy* or better. Field-run standard Delicious apples, harvested at prime maturity for fresh market or storage, were used in preparing juice for blending.

One harvest was made each season of the Golden Delicious and Winesap varieties at a maturity considered prime for fresh market or storage, since the bulk of these varieties is harvested commercially at a comparatively uniform maturity. Golden D licious was handled as a field-run grade. The Winesaps were segregated into *fancy to extra-fancy* combination grade, C grade, and cull according to commercial standards for color and size with small fruits (smaller than 175 per packed box) graded as cull regardless of color. The cull and C grade fruit represented the bulk of Winesap apples available to juice processors from fresh fruit packing houses.

In 1953 a special, early harvest was made of the Winesap variety to study the possible use of immature Winesaps to extend the available supply of tart varieties for blending with low-acid Delicious. Immature fruit of this variety could be obtained in commercial quantities from a pre-harvest color picking of C and cull grade fruit. The practicability of such a picking has been considered by various growers to eliminate packing-house handling costs on this lower-quality fruit. Harvest maturity data on each harvest of fruit used in these studies are summarized in Table 1.

**Fruit handling methods.** All samples were taken to Prosser on the day harvested and each lot was carefully composited to assure uniformity of samples. Eight boxes of each maturity and grade, except the immature Winesap harvest in 1953, which consisted of a single 2-box lot, were stored for use in studying the effect of ripening at ambient temperature on juice quality. Weekly average temperatures of the storage in 1952 ranged from 81° F. (27.2° C.) during the early Jonathan study to 63° F. (17.2° C.) during the Winesap study later in the season with short period extremes of 87° F. and 60° F. (30.6° C. and 15.6° C.). The season was somewhat cooler in 1953 when weekly average ripening temperatures ranged from 72° F. (22.2° C.) during the early season to 60° F. (15.6° C.) during the later ripening periods with short period extremes of 84° F. and 58° F. (28.8° and 14.4° C.). The relative humidity during both seasons averaged about 46% with short-period extremes of 70 and 36%.

One 2-box lot of each grade from each of the Jonathan and Golden Delicious harvests was pressed the day after harvest and duplicate lots were pressed 1, 2, and 4 weeks after picking. One 2-box lot of each grade of the Winesap harvests was pressed the day after harvest. Duplicate lots were pressed 2, 4, and 6 weeks after picking except for the immature harvest which was pressed only on the day after harvest. The shorter ripening periods for the Jonathan and Golden Delicious were selected because of the rather high ambient temperature during the ripening period. The standard Delicious were ripened 3 weeks before pressing to obtain a full-flavored juice for blending with juice from the Jonathan and Winesap varieties. Decay was not a problem with any variety during these ripening periods.

**Juice preparation.** All juices were prepared, clarified, and processed by a standard procedure described in a previous study on Delicious apples *(3)*.

**Juice blends.** A series of blends was prepared in which juices from various lots of Jonathan or Winesap were mixed with juice from the ripened standard Delicious. The proportion of Delicious juice was calculated from the acid content to give blends containing 0.4% acid, as malic. To further minimize flavor differences other than apple, a small amount of sucrose was added to bring the total sugar content of all blends used in a given taste test up to that of the sweetest blend. The amount of sucrose added never exceeded 0.9% and was usually less than 0.1%.

**Analytical methods.** Procedures for sample selection, pressure test, and chemical analyses were the same as described in a previous article *(3)*. The small size of the cull Winesap fruit precluded measurement of firmness on that grade. A mechanical flaw in a pressure tester, discovered during the 1952 season,

[a] A laboratory of the Western Utilization Research Branch, Agricultural Research Service, U. S. Department of Agriculture.

[b] Part of the Washington Agricultural Experiment Stations, State College of Washington, Pullman, Washington.

**TABLE 1**

**Harvest maturity data for apples used in study**

| Variety | Harvest date | Days from full bloom | Description of maturity [1] |
|---|---|---|---|
| Jonathan | Sept. 8, 1952 | 131 | Commercial harvest for early fresh market—hard. |
| | Sept. 24, 1952 | 147 | Prime for fresh market or storage—hard. |
| | Sept. 14, 1953 | 138 | Commercial harvest for early fresh market—firm. Slightly riper than comparable 1952 harvest. Average firmness; *fancy-extra fancy* grade = 17 lbs., C grade = 18 lbs. |
| | Sept. 30, 1953 | 154 | Prime eating ripe, crisp, juicy. Probably past prime maturity for storage. Average firmness; Field-Run grade = 15 lbs. |
| Golden Delicious | Sept. 24, 1952 | 147 | Prime for fresh market or storage—hard. |
| | Sept. 30, 1953 | 154 | Prime for fresh market and storage, hard. Average firmness; Field-Run grade = 20 lbs. |
| Winesap | Oct. 15, 1952 | 168 | Prime for fresh market or storage—hard. Average firmness; *fancy-extra fancy* grade = 24 lbs. C grade = 25 lbs. |
| | Sept. 30, 1953 | 154 | Immature—hard flesh slightly green. Average firmness; Field-Run grade = 24 lbs. |
| | Oct. 20, 1953 | 174 | Prime for fresh market or storage—hard. Average firmness; *fancy-extra fancy* grade = 25 lbs., C grade = 24 lbs. |

[1] Firmness values obtained with Magness and Taylor *(2)* pressure tester using 5/16-inch plunger on pared surface at 3 points around circumference of each of 20 apples.

prevented use of some of the pressure-test data obtained during that season. A 1:1 ratio of alcohol to fruit was found to give incomplete extraction of tannin and accounts for the low tannin values reported for Delicious flesh *(3)*. The method was therefore modified in this study to give an extract prepared by grinding 50 g. of sample with 300 ml. of 95% ethyl alcohol. The rapid, colorimetric starch procedure is described in another article *(1)*.

**Taste tests.** The comparative taste quality of the juices was determined by the triangle difference test and by scoring. The triangle difference test was conducted in the manner previously described *(3)* using a panel of 21 judges with about 16 participating in each test.

Five samples were presented in random order in one series of scoring tests to determine the relative flavor of juices prepared from single varieties of apples of similar history except for the post-harvest ripening treatment. The judges were requested to score on a 1-to-10 scale on the basis of desirable apple flavor, with the poorest given a score of 1 and the best a score of 10. These limits were set to eliminate a tendency of judges to score one variety or grade against another that had been tasted in a previous test. A second series of scoring tests was made on samples of blended juices. In these tests the judges were asked to score 6 blends, two of which were identical, on a scale of 1 to 10 without restrictions on the score given to the best or poorest blend. In each test the scores of those who failed to give comparable values to the duplicates were eliminated.

## RESULTS AND DISCUSSION

**Chemical composition.** Pressure-test values and data on chemical composition of fruit and resulting juices at harvest and after various periods of ripening are presented in Figures 1 and 2 for each of the varieties and grades harvested in 1953. These data, which show a decrease in firmness and in acid and starch content and an increase in sugars during ripening, are presented primarily to serve as indexes of the maturity and condition of each lot of fruit at time of processing into juice.

Data obtained in 1952 showed similar trends and are not shown. Slightly lower total and reducing-sugar and slightly higher starch, acid, and tannin contents indicated that the Jonathan variety was harvested at slightly less mature stages in 1952 than in corresponding harvests in 1953. A slightly higher total-sugar and a lower starch content, 0.67% compared with 1.1%, in the Golden Delicious harvested in 1952 suggested that the 1952 harvest was more mature than the 1953 harvest. The acid and tannin contents were considerably higher in 1952, however.

The total and reducing-sugar contents of all grades of Winesaps harvested in 1952 were appreciably higher than that shown for 1953. This deviation was most pronounced in the cull grade where differences were in the order of 2% as compared with about 1% for the other grades. The starch contents were comparable in the 2 seasons for the *fancy to extra-fancy* grades but were appreciably lower in 1952 for the C and cull grades.

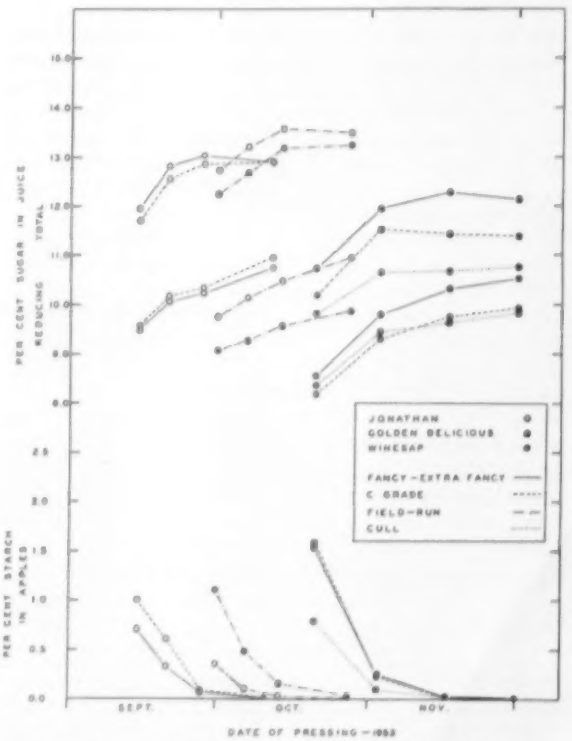


**Figure 1. Changes in starch content of flesh and sugar content of juices from apples of several maturities, grades, and varieties, during post-harvest ripening.**

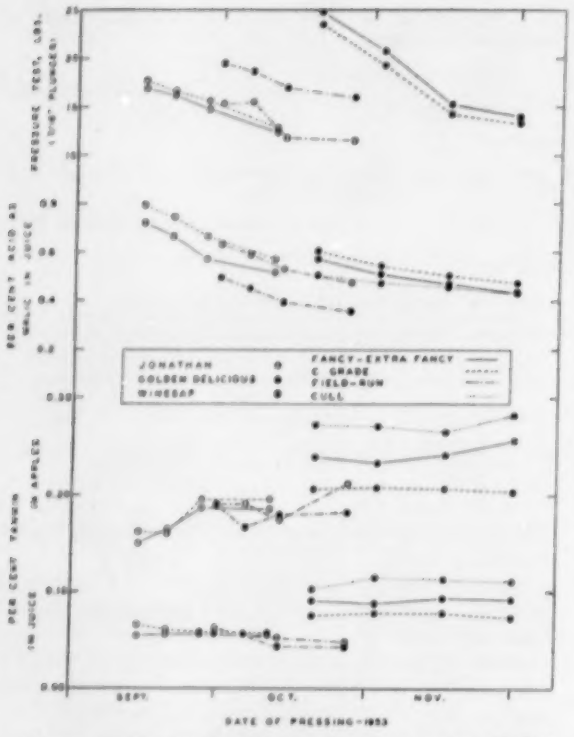


**Figure 2. Changes in firmness and tannin content of flesh and acid and tannin content of juices from several maturities, grades, and varieties of apples during post-harvest ripening.**

Tannin contents were comparable for all grades in both seasons but the acid contents of the cull grade in 1952 was higher than that of the C grade. Analyses of the immature harvest of Winesap, not presented in Figures 1 and 2, showed this fruit to contain 2.25% starch and 0.20% tannin while the juice contained 9.79% total sugars, 8.05% reducing sugars, 0.65% acid, and 0.075% tannin.

**Flavor of single-variety juices.** Significant differences ($p<0.01$) were found in triangle taste comparisons of juices from *fancy to extra-fancy* and C grade Jonathans of similar ripening treatment over the entire ripeness range in both seasons. In all cases juices from the *fancy to extra-fancy* fruit were considered to be sweeter, less tart, less astringent, and to have a more pronounced apple flavor. Similar differences and flavor comments were obtained when juices from *fancy-to extra-fancy* and C grade Winesaps of similar ripening treatments were compared. Differences between juices prepared from C and cull grade Winesaps were not so pronounced. Differences were significant ($p<0.01$) only when these grades had been ripened 2 and 4 weeks. Where significant differences were found, juice from the C grade fruit was considered to have a more pronounced apple flavor while that from the culls was considered to be more astringent.

Results of scoring-test evaluations of juices prepared from fruits after different post-harvest ripening periods during both seasons are shown in Table 2 for each variety, grade, and harvest maturity. Juice with the most desirable flavor was obtained from early-fresh-market Jonathans of both grades when the fruit had been ripened 2 to 4 weeks after harvest. When Jonathan and Golden Delicious were harvested at prime fresh-market maturity, the most desirable flavor was attained after 1 to 2 weeks' ripening. Flavor was found significantly less desirable ($p<0.01$) in 2 out of 4 tests with 4 weeks' ripening. The best-flavored juices from all grades of Winesap were obtained when the fruit had been ripened 2 weeks, and the flavor was found to be less desirable ($p<0.01$) when the fruit was ripened 6 weeks.

In scoring tests it is impossible to eliminate the factor of personal preference. Comments by panel members indicated, however, that juices from these varieties had an undesirably tart, astringent flavor when prepared one day after harvest. None of these varieties developed as pronounced an aromatic flavor during post-harvest

**TABLE 2**

**Effect of post-harvest ripening on flavor of single variety juices**

| Fruit used in preparing juice | Year | Mean scores of 10 to 15 judges (1 to 10 scale: 1 = poorest and 10 = best flavor) | | | | | L. S. D.[1] | |
|---|---|---|---|---|---|---|---|---|
| | | Time ripened after harvest | | | | | .05 | .01 |
| | | 1 day | 1 week | 2 weeks | 4 weeks | 6 weeks | | |
| Fancy to Extra-Fancy Jonathan, 1st harvest | 1952 | 1.00 | 4.00 | 8.21 | 8.82[2] | ..... | 1.13 | 1.51 |
| | 1953 | 1.23 | 5.38 | 9.27[2] | 7.61 | ..... | 1.27 | 1.70 |
| C grade Jonathan, 1st harvest | 1952 | 1.00 | 2.07 | 7.32[2] | 8.71 | ..... | 1.34 | 1.79 |
| | 1953 | 1.00 | 6.04[2] | 8.20 | 7.80 | ..... | 1.60 | 2.13 |
| Field-run Jonathan, 2nd harvest | 1952 | 2.92 | 8.38 | 8.31 | 4.31[2] | ..... | 2.26 | 3.01 |
| | 1953 | 2.08 | 7.38[2] | 7.58 | 7.33 | ..... | 2.29 | 3.06 |
| Field-run Golden Delicious | 1952 | 1.31 | 7.85[2] | 7.62 | 5.08 | ..... | 2.14 | 2.85 |
| | 1953 | 3.71 | 7.86[2] | 7.64 | 3.50 | ..... | 2.28 | 3.05 |
| Fancy to Extra-Fancy Winesap | 1952 | 1.08 | ..... | 9.31 | 7.31[2] | 4.31 | 1.30 | 1.74 |
| | 1953 | 1.00 | ..... | 8.73 | 8.60[2] | 5.91 | 1.57 | 2.10 |
| C grade Winesap | 1952 | 3.50 | ..... | 8.75[2] | 5.21 | 2.21 | 1.86 | 2.48 |
| | 1953 | 1.71 | ..... | 8.68[2] | 6.43 | 4.43 | 1.40 | 1.87 |
| Cull Winesap | 1952 | 1.90 | ..... | 9.30 | 7.70 | 5.35[2] | 2.25 | 3.01 |
| | 1953 | 1.54 | ..... | 8.46[2] | 7.46 | 3.62 | 1.78 | 2.38 |

[1] Least significant difference.
[2] Sample presented in duplicate.

ripening as has been found characteristic of standard Delicious *(3)*. Low scores given juices prepared from fruit ripened beyond the optimum time were due to lack of flavor, lack of freshness in flavor, or because the juice was considered insipid.

**Flavor of blended juices.** Studies on the juice quality of single varieties, while useful in evaluating handling methods, have limitations in practical application because most commercial juices are prepared from blends of two or more varieties. The relative blending quality of juices prepared from the Jonathan and Winesap of varied ripeness with juice from fully ripened Delicious was studied with scoring tests. The Jonathan-Delicious blends used in certain tests are presented in Table 3 together with scoring results. Differences in apple flavor between the Jonathan-Delicious blends were not significant ($p>0.05$) in the 1952 tests and difference bordered on significance ($p<0.05$) only for blends prepared with juices from unripened Jonathans or Jonathans ripened 4 weeks in 1953. No significant differences were found in a similar test between blends prepared with juice from *fancy to extra-fancy* Jonathans and Delicious in 1953. Most judges considered the blends to be very similar in flavor.

**TABLE 3**

**Flavor comparisons of different Jonathan juices in blends with full-flavored Delicious juice (juices proportioned to give blends containing 0.40% acid, as malic, and sucrose added to give uniform total sugar content in all blends in each test)**

| Fruit used in preparing juice for blending with juice from fully-ripened standard Delicious | Standard Delicious juice in blend, % | | Mean scores of 14 to 15 judges[1] | |
|---|---|---|---|---|
| | 1952 | 1953 | 1952 | 1953 |
| C grade Jonathans from first harvest—ripened 1 day | 75.2 | 69.5 | 6.08 | 5.93 |
| C grade Jonathans from first harvest—ripened 1 week | 74.2 | 66.9 | 5.92 | 6.79 |
| C grade Jonathans from first harvest—ripened 2 weeks | 65.6 | 60.7 | 6.63[2] | 7.47[2] |
| C grade Jonathans from first harvest—ripened 4 weeks | 45.4 | 49.9 | 6.17 | 5.79 |
| Field-run Jonathans from second harvest—ripened 1 day | 44.9 | 57.8 | 5.75 | 5.36 |

[1] F value showed differences not significant ($p>0.05$) in 1952. L. S. D. 0.05 = 1.56 in 1953 study.
[2] Samples presented in duplicate.

The Winesap-Delicious blends used in scoring tests are presented in Table 4 together with scoring results. The best flavor was obtained in all tests when the Winesaps had been ripened two weeks or less. A significantly less desirable flavor ($p<0.01$) resulted when this variety was allowed to ripen 4 to 6 weeks after harvest. Of particular interest is the fact that the blend prepared from the early, immature, field-run harvest was found to have a significantly better flavor ($p<0.01$) than any of the blends prepared with cull grade fruit from the prime-maturity harvest.

These results indicate that use of unripened Jonathan apples picked at an early-fresh-market maturity, when blended with ripened Delicious, would permit as much as a two-fold increase in volume of blend over that obtained from ripened Jonathans without appreciable loss in juice quality. Similar increases were obtained with unripened Winesap and the increase would be even greater if the fruit were harvested before the main harvest for fresh market. It should be emphasized that these observations are probably valid only when juice from fully-ripened Delicious is used. The greater proportion of highly flavored Delicious juice permitted

**TABLE 4**

**Flavor comparisons of different Winesap juices in blends with full-flavored Delicious juice (juices proportioned to give blends containing 0.40% acid, as malic, and sucrose added to give uniform total sugars content in all blends in each test)**

| Fruit used in preparing juice for blending with juice from fully-ripened standard Delicious | Standard Delicious juice in blend, % | | Mean scores of 14 to 16 judges | |
|---|---|---|---|---|
| | 1952 | 1953 | 1952 | 1953 |
| C grade Winesap ripened 1 day | 56.3 | 54.2 | 7.56 | 6.93 |
| C grade Winesap ripened 2 weeks | 44.9 | 45.2 | 6.91[2] | 6.65[2] |
| C grade Winesap ripened 4 weeks | 31.3 | 37.1 | 4.44 | 4.64 |
| C grade Winesap ripened 6 weeks | 21.0 | 30.2 | 3.19 | 2.29 |
| Cull Winesap ripened 2 weeks | 49.7 | ..... | 6.31 | ..... |
| Field-run grade Winesap[1] ripened 1 day | ..... | 59.0 | ..... | 6.36 |
| L. S. D. 0.05 = | ..... | ..... | 1.25 | 1.39 |
| L. S. D. 0.01 = | ..... | ..... | 1.66 | 1.85 |
| Cull grade Winesap ripened 1 day | ..... | 37.8 | ..... | 6.20 |
| Cull grade Winesap ripened 2 weeks | ..... | 30.2 | ..... | 5.60[2] |
| Cull grade Winesap ripened 4 weeks | ..... | 24.7 | ..... | 2.33 |
| Cull grade Winesap ripened 6 weeks | ..... | 15.3 | ..... | 1.40 |
| Field-run grade Winesap[1] ripened 1 day | ..... | 59.0 | ..... | 7.80 |
| L. S. D. 0.05 = | ..... | ..... | ..... | .99 |
| L. S. D. 0.01 = | ..... | ..... | ..... | 1.32 |

[1] Samples presented in duplicate.
[2] Immature fruit from the Sept. 30, 1953 Winesap harvest (see Table 1).

appears to compensate for lack of apple flavor in the unripened Jonathan and Winesap. To take advantage of this saving in amount of tart varieties required for blending in commercial production, it would be necessary to place juice fruit of these varieties in cold storage promptly after harvest in order to hold it at the desired maturity until needed for blending with ripened Delicious. Cold storage would also tend to reduce the deterioration in juice quality observed with increasing ripeness of these varieties.

If the supply of juice-quality Delicious exceeds the supply of tart varieties, as it frequently does in the Pacific Northwest, the ideal fruit handing method would be to leave poorly colored Delicious on the tree when the fresh-market harvest is made for later harvest as juice fruit, and to harvest poorly colored Jonathan and Winesap fruit for juice before the commercial harvest. The juice fruit of the Delicious would be ripened at least 2 weeks and blended with unripened juice fruit of the Jonathan and Winesap varieties. Such a practice would permit a maximum extension of a short supply of tart varieties for blending with an excessive supply of Delicious without appreciable loss in juice quality. The cost of making separate harvests of juice fruit may be more than compensated by the elimination of packing house handling costs for the juice grade fruit.

## SUMMARY AND CONCLUSIONS

The effects of ripeness and grade on the composition and quality of juice from Jonathan, Golden Delicious, and Winesap apples were investigated. The relative blending quality of juices from Jonathan and Winesap

apples at several stages of ripeness with juice from fully-ripened Delicious apples was studied.

Juices from *fancy to extra-fancy* fruit of Jonathan and Winesap were higher in sugars, lower in acid, and had a more desirable apple flavor than those from C grade fruit of the same variety and ripening treatment. Juices from cull Winesap apples were comparable or slightly less flavorful than those from C grade fruit of the same ripening treatment. Post-harvest ripening of all fruits was accompanied by a decrease in firmness, a loss of starch and acid, and an increase in sugar.

Post-harvest ripening for at least one week was found necessary to avoid an undesirably sharp, astringent flavor in juices prepared from these varieties. A ripening period of 2 to 4 weeks was found desirable for Jonathans when picked before optimum maturity for fresh market. Unlike Delicious, these varieties did not develop a pronounced aromatic flavor during post-harvest ripening, and when picked at optimum maturity for fresh market, 4 to 6 weeks' ripening resulted in juices of poor flavor.

The advantage of post-harvest ripening for Jonathan and Winesap was not apparent when juices from these varieties were used in blends with juice from fully-ripened Delicious. Use of unripened fruit of the Jonathan and Winesap permitted inclusion of a considerably higher proportion of Delicious in preparing blends of uniform acid content without appreciable loss of flavor.

**Acknowledgments**

The authors express their appreciation to volunteers of the Irrigation Experiment Station staff for their faithful participation in the taste panel.

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# Effect of Dilution Upon Mold Counts of Raspberries by the Howard Method[a]

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(Manuscript received July 28, 1954)

**The effect of dilution on mold count of raspberries, using the Howard method, was studied. Although the effect of dilution is determined largely by the amount of mold initially present, it is shown that dilution of intermediate and low count samples changes the mold count considerably. There appears to be no reason to change from a 1:1 dilution, the one predominantly in use, and it is suggested that it might be desirable to adopt it as the standard procedure.**

The microscopic method described by Howard *(3)* in 1911 for estimating mold in tomato products was revised and standardized by Howard and Stephenson *(4)* in 1917. The method is widely used and serves a very useful function in the control of quality of tomato products. Its application to raspberries and other small fruits susceptible to mold spoilage has not been so extensive.

No specific directions are given for the estimation of molds in raspberries by the Howard method in *Official and Tentative Methods (1)*. The practice has been to use a combination of the methods described for cranberries and tomatoes. This calls for dilution of the pulped raspberry sample with 3% pectin on a weight for weight basis. The pectin serves to keep the mold fragments and other insoluble materials in uniform suspension and to dilute the raspberry pigments and cells. Since mold fragments are more easily identified in the diluted than in the undiluted sample, counting is simplified.

Although a 1:1 dilution has been commonly used, it is in no sense official. No information is available in the literature indicating the effect dilution plays on mold counts obtained by the Howard method or why a 1:1 dilution should be used. In fact, some of the U. S. Department of Agriculture raw product inspectors use a 1:2 dilution—supposedly because it facilitates making mold counts on raspberries.

In view of the lack of information regarding the effect of dilution on mold count of raspberries, it was considered advisable and necessary to study in detail the relationship between dilution of samples and mold count.

## EXPERIMENTAL METHODS

Raspberry samples with a wide variation in initial mold contamination were collected from several commercial canning plants in western New York and from the New York State Agricultural Experiment Station plantings. Each sample was pulped in a Cefaly laboratory pulper-finisher containing an 0.027-in. screen, and then was deaerated under vacuum. Mixed samples of the pulped berries were diluted by weight to various berry concentrations with 3% pectin solution. Each sample and each dilution of the samples were counted by 2 technicians trained in the use of the Howard method *(1)*.

In view of the variation to be expected in individual mold counts due to sampling errors *(5, 6)* on a purely statistical basis,

[a] Journal Paper No. 971, New York State Agricultural Experiment Station, Cornell University, Geneva, New York, 1954.

no emphasis was placed on the results of any single dilution series. Conclusions were based completely on trends which appeared when the results of individual dilution series were combined and the mean values plotted.

## RESULTS AND DISCUSSION

In 1952, the 57 samples diluted and counted were grouped on the basis of their mold counts. These subgroups contained 14 or 15 samples in the following mold count ranges (1:1 dilution): 4-20, 22-48, 52-72, 74-98. Mold counts obtained on the various dilutions within each group were averaged. In 1952, major emphasis was placed on changes in mold count as samples were diluted from 50% to 6% berries. In 1953, thirty-one samples were diluted and counted with the major emphasis being placed on the change in mold count as the samples passed from the undiluted to the 33% berry level.

These mean mold counts of the diluted samples plotted against the percent raspberry in the various dilutions are shown in Figure 1. The counts are percent microscopic fields position for mold. They have not been adjusted to take into account the dilution factors. The results clearly show that the effect of dilution upon mold count is determined to a great extent by the amount of mold initially present. If the initial mold count is high, the mold count will fail to decrease appreciably as the sample is diluted as far as 1:1. If the initial mold count is low, the mold count will fall proportionately as the raspberry concentration is decreased. If the initial mold count is between the upper and lower ranges, it will show an intermediate behavior as the sample is diluted. This is in general agreement with unpublished work of Greenleaf *(2)* who calculated mathematically the probable effect of dilution on mold count of tomato products.

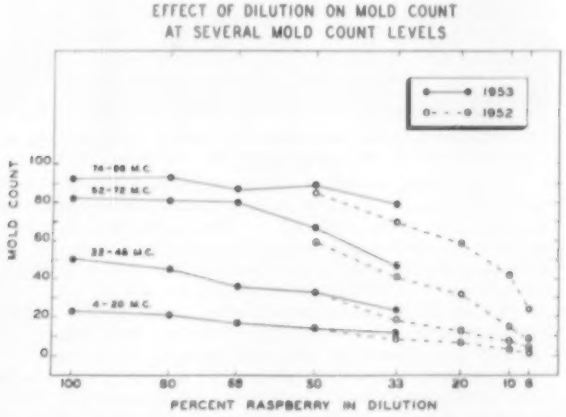


**Figure 1. Effect of dilution on mold count at several mold count levels.**

From a practical viewpoint, it is clear that dilution has little effect upon the mold count of highly contaminated samples. However, dilution of low mold count samples will change the mold count considerably. The controversial samples and also the most important are the intermediate mold count samples which may be subject to seizure by the FDA. The amount of dilution of such samples is very important.

Dilution of the raspberry pigments is essential to facilitate mold counting. It seems that there is little choice between a 1:1 dilution and a 1:2 dilution. Mold filaments will stand out somewhat more clearly in the 1:2 dilution than in the 1:1. The higher dilution would tend to favor the processor. In view of the fact that a 1:1 dilution has been used more than the 1:2 dilution in the past, it might be desirable to adopt the 1:1 as the standard procedure.

## SUMMARY

Mold counts were run by the Howard method on samples of raspberries before and after dilution of the pulped berries with 3% pectin solution. It was found that the higher the mold count of the sample, the less effect dilution had upon the mold count. Mold counts on samples containing little mold decreased proportionally to the decrease in berry concentration. Berry samples with medium amounts of mold showed an intermediate behavior depending upon the initial mold count.

### Acknowledgment

The authors acknowledge their indebtedness to Mrs. Margaret Albury for technical assistance during the summers of 1952 and 1953, to Professors George Slate and Robert Lamb for reserving sections of the New York State Agricultural Experiment Station plantings for use in this study, and to members of the New York State Canners and Freezers Association who furnished samples of berries.

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# Problems in the Production of Tomato Juice Powder by Vacuum[a]

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(Manuscript received July 19, 1954)

**Production by vacuum drying of a tomato-juice powder which readily reconstitutes with cold water to a full-bodied juice has been found feasible. Two general methods have been developed. Variables investigated include: composition and degree of concentration of the original juice, shelf and product temperatures during drying, bulk density of finished product, and effect of pulp or insoluble solids on drying characteristics. Need for incorporating volatile flavors is discussed.**

Recent developments in stable citrus-juice powders *(10)* have led to the extension of such investigations to include tomato-juice powder. Such a product may find outlets for civilian as well as military uses, owing to the potential reduction in packaging and distribution costs. Only a few references on dehydration of tomato juice or paste, either by spray drying, drum drying, or other means *(1, 2, 3, 7, 12)* have been found. During World War II a plant was built at Riverbank, California, to produce drum-dried tomato flakes but was operated for only a short time. A limited amount of tomato flakes is produced at this time by drum drying for use in soups.

A procedure has been described by Strashun and Talburt *(9, 10)* for converting concentrated orange juice containing 60 to 70% soluble solids to powder by vacuum drying in such a way as to produce puffing. This procedure makes possible rapid drying at low temperatures and yields a product which is easily removed from the trays and dissolves readily in water. In applying the same procedure to concentrated tomato juice it was found that the two concentrates are different in several respects that require changes in procedure for the tomato powder.

Differences in pulp or insoluble-solids content between tomato and orange juice are the most important factors. Whereas reconstituted high-density orange concentrate (12% total solids) contains only about 5% insoluble solids when determined volumetrically by centrifuging, commercial samples of tomato juice with 6% total solids contain up to 30% of insolubles. Pulp in tomato juice is desirable, since it contributes greatly to consistency; the juice seems watery and thin if deficient in pulp. In addition, much of the red pigment of tomatoes, lycopene, is associated with the pulp. This amount of pulp, however, presents problems during concentration of tomato juice and limits the degree of concentration that can be achieved in commercial tomato equipment to about 40% solids. At this point, the consistency of the tomato concentrate is so heavy that further concentration is not practicable.

The physical characteristics of this material are such that it cannot be "puff-dried" by procedures used in drying concentrated orange juice. Instead of the expanded open structure obtained in orange solids, the tomato concentrate dries slowly to a hard glassy material while maintaining approximately its original dimensions or even shrinking slightly. The product obtained reconstitutes very slowly.

The lower solids content of tomato paste as compared to high-density orange concentrate presents an additional problem, at least from an economic standpoint, in that almost twice as much water must be evaporated from tomato paste in order to produce a pound of dry solids.

## DRYING PROCEDURES

In the course of the work, 2 procedures have been developed that can be used in preparing tomato powder: (a) a direct vacuum drying procedure by which high-density tomato paste can be converted in one step to a powder and (b) a split drying procedure in which the tomato pulp is separated from the serum of single-strength juice, the serum is concentrated, the serum and pulp are dried separately, and the serum solids and pulp are recombined in the right proportions *(9)*.

**Direct drying procedure.** Most of the developmental work on tomato powder to date has been concerned with direct drying. Incorporating finely dispersed air into the tomato concentrate, prior to vacuum drying, causes the paste to expand, and the tomato solids can then be dried to a product that is similar in appearance to puff-dried orange solids.

The actual mechanism of puffing in orange seems to differ from that in tomato concentrates. Strashun and Talburt *(10)* showed that thoroughly deaerated concentrated orange juice could be expanded to 15 to 20 times its original volume during drying. Since entrapped gases and gases in solution were largely removed, it seems likely that release of water vapor is largely responsible for expansion. Similar expansion could not be obtained with tomato pastes which contained normal amounts of pulp without first incorporating a considerable volume of air finely dispersed in the paste.

In preparing tomato powder by direct drying, high-density paste (up to 38% solids) was placed in the bowl of a heavy-duty upright mixer equipped with a wire whip and beaten until its apparent density was decreased to about 0.9 g./ml. The time required to disperse this amount of air varied with lots and with temperature of paste. Mixing time ranged from 5 to 20 minutes at room temperature. At lower temperatures proper mixing could be effected in shorter times. The aerated paste was weighed into shallow stainless-steel pans (3 ft. x 1 ft.) at the rate of 0.5 lb. per sq. ft. and the viscous material was spread evenly since its consistency was such that it would not flow (Figure 1).

The loaded trays were then placed in a vacuum shelf dryer, the pressure reduced to about 1 mm. of Hg., and the temperature of the shelves was raised to 220° F. (104.5° C.) as rapidly as possible. The incorporated air caused a 10- to 15-fold expansion of the paste during the early stages of drying. As the product temperature increased, the shelf temperature was decreased, so that the temperature of the tomato solids did not rise above 150° F. (65.6° C.). Above the latter temperature, heat damage occurred. With addition of 0.05% of sodium bisulfite (as $SO_2$) to the paste prior to drying, the maximum product temperature without heat damage was at least 190° F. (87.8° C.) and drying time could be reduced from 2.5 hours to about one hour. Satisfactory drying was obtained with 3 mm. Hg. pres-

[a] Presented at the Fourteenth Annual Meeting of IFT, June 29, 1954, Los Angeles, California.

**Figure 1. Procedure for spreading aerated tomato juice concentrate uniformly on bottom of drying trays.**

sure maintained in the dryer, but at this pressure the drying time was almost doubled.

Conditions used in a typical drying cycle are shown in Figure 2. Temperatures were measured with thermocouples placed 1/16 inch from the bottoms of trays. After sufficient drying to reach about 3% moisture the temperature of the product was lowered by circulating cold water through the hollow shelves, the vacuum was released, and the solids were removed from the trays. Figure 3 shows trays of dried tomato solids as removed from the dryer. The solids were comminuted to pass a 10-mesh screen and packaged in hermetically sealed containers. Grinding and packaging were carried out in a room maintained at 10% relative humidity or less.

This direct drying procedure works quite satisfactorily in the batch-type drying equipment used in the laboratory experiments. It may not be feasible, or even possible, to use this process in existing types of continuous dryers, owing to excessive deaeration before the paste can be applied to the drying surface. Under these conditions, puffing may not occur. For continuous dryers the split drying procedure or a modification of this procedure may be more satisfactory.

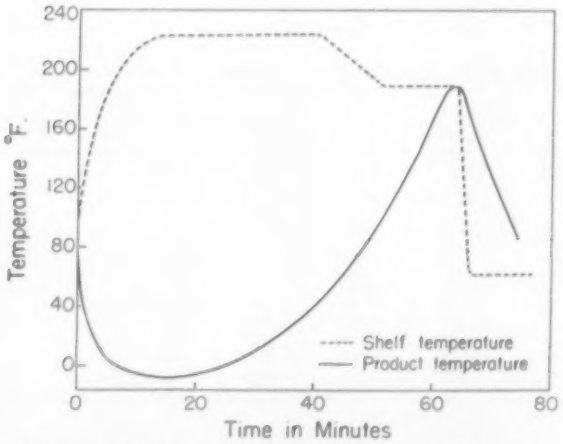


**Figure 2. Drying cycle for converting concentrated tomato juice with added sodium bisulfite to powder by direct drying procedure. Pressure, 1 mm. of Hg.**

**Split drying procedure.** Single-strength canned tomato juice was run through a high-speed bowl-type centrifuge so as to separate 90 to 95% of the pulp from the serum. The serum was then concentrated to 62° to 65° Brix in a vacuum pan operating at about 15 mm. Hg. with a jacket temperature of 135° F. (57.2° C.). The concentrated serum was poured into stainless-steel trays at the rate of 0.5 lb. per sq. ft. The loaded trays were placed in a vacuum shelf dryer, the pressure was reduced to 3 mm. of Hg., and the shelf temperature was raised to 220° F. (104.5° C.). The serum dried and puffed in much the same manner as orange concentrate. With this procedure concentrated tomato serum can be puff-dried to 3% moisture in about one hour. Prior incorporation of air is not required.

The tomato pulp was vacuum dried or air dried and added back to the serum solids in the right proportion. This material is more difficult to reconstitute and requires more time than that prepared by direct drying.

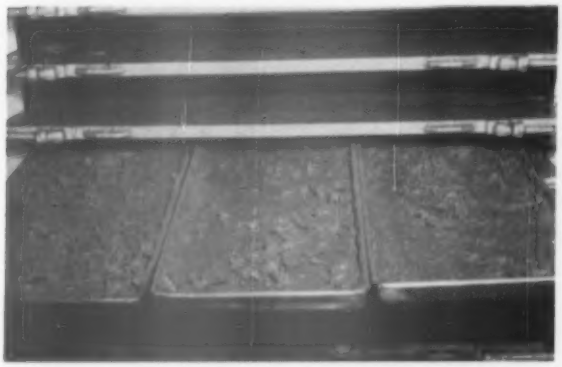

**Figure 3. Trays of tomato juice powder being removed from dryer.**

A variation of this procedure, which may offer several advantages, consisted of adding pulp from the centrifuge to the concentrated serum. This mixture was flowed on trays without incorporation of air. It was found that up to 15% of pulp by volume, as measured by centrifuging reconstituted juice (6% solids), could be returned in this manner, with successful puff drying. This variation also offers a means of controlling the amount of expansion during drying, since expansion decreases with increasing pulp content.

Such a procedure would permit the preparation of a concentrate with considerably higher solids content than is obtainable with commercial pastes, thus reducing the pounds of water to be evaporated per pound of dry solids. Expansion of the tomato solids without use of entrapped air might make the process more readily adaptable to drying on a continuous scale, as has been done for orange juice powder. The obvious disadvantage, aside from the extra cost of centrifuging, is the reduced amount of tomato pulp that can be added to the serum solids, which reduces somewhat the yield from a given amount of tomatoes and undoubtedly yields a somewhat thinner juice upon reconstitution. However, when pulp is returned to the extent of 15% as measured volumetrically by centrifuging, color and consistency of the reconstituted juice are good. A somewhat similar drying procedure could be employed with paste prepared from tomatoes in such a way as to limit the amount of pulp extracted during preparation of the juice.

## ANALYTICAL METHODS

Moisture was determined by vacuum oven at 149° F. (65° C.) for 16 hours and by a modification of Karl Fischer procedure *(5)*. The 2 methods agreed quite closely. Free and suspended

pulp was determined by centrifuging for 30 minutes at 2,000 r.p.m. (16 in. diameter). All samples of powder and paste were reconstituted by diluting to 6% solids by refractometer. Ascorbic acid was determined by the Loeffler and Ponting method *(4)* and reductones by that of Wokes *et al. (13)*. Anhydrouronic acid, an index of pectin content, was determined by the method of McCready and McComb *(6)* and sulfur dioxide was assayed by a modification of the Monier-Williams procedure *(8)*.

## EFFECT OF RAW-MATERIAL VARIATION ON DRYING

Several different samples of commercial tomato pastes, ranging in solids contents from 25 to 46%, and a 38% paste prepared by concentrating a commercial canned single-strength tomato juice, were used in these studies. All of these could be dried satisfactorily by the direct-drying process except 2 samples of paste containing 46% solids. The consistency of the latter samples, both cold and hot break, was so heavy that sufficient air could not be incorporated by heating to cause puffing during drying. When diluted with water to 38% solids, these 2 samples dried satisfactorily. Pulp or suspended solids in these various pastes, as determined by centrifuging, ranged from 14 to 25% (Table 1) by volume when reconstituted to 6% solids.

## EFFECT OF RAW-MATERIAL VARIATION ON RECONSTITUTION

Samples of dry tomato solids showed a considerable range in bulk density, varying from 0.21 to 0.46 g./ml., depending on the amount of puffing that occurred during drying. A bulk density of about 0.3 seemed to be nearly optimum, as it permitted rapid reconstitution with cold water without too great a sacrifice in container space. One volume of powder with this density can be reconstituted by adding 4 volumes of water to give a tomato juice with 6% solids. Powders with greater bulk density can be prepared by reducing the amount of air incorporated in the paste, but with increasing bulk density, reconstitution time is increased.

**Effect of direct drying.** In reconstituting powders prepared by direct drying, water is added and the mixture is stirred until thoroughly wetted. The granular particles are wetted easily and show no tendency to clump. As rehydration proceeds, the individual fibers of the pulp are progressively released and the normal consistency or body of the juice is obtained.

Time required for reconstitution in cold water varied markedly with powders prepared from various lots of paste, ranging from 2 minutes to several hours with nearly all of the samples requiring from 2 to 4 minutes. Attempts were made to correlate reconstitution rate with chemical composition. Results of rather extensive analyses of tomato paste are shown in Table 1.

There is some indication that pectin content affects the way the powders reconstitute. Anhydrouronic acid values given in the table were determined on a moisture-free and ash-free basis and can be converted to approximate pectin values by multiplying by the factor 1.4. In general it was found that samples of paste containing low amounts of soluble anhydrouronic acid (below about 2% dry basis) did not reconstitute readily. Additional information was obtained by taking 2 aliquots of a tomato paste containing a high percentage of soluble pectin, treating one with pectinolytic enzymes and converting both to powders by direct drying. The untreated sample reconstituted readily in cold water within 2 minutes, while the treated samples did not reconstitute even on prolonged boiling. Where reconstitution difficulties are encountered, small discrete particles, visible to the eye, remain in the juice. These may be of such size that they settle rather rapidly. When properly reconstituted, consistency, color, and sedimentation rates of reconstituted powders are similar to those of single-strength juice.

**Effect of split drying.** Tomato juice powder prepared by split drying is difficult to reconstitute in cold water. Wetting of the pulp fraction is difficult and there is some tendency for the pulp to clump. Reconstitution is rapid in hot water. Powders prepared by adding a portion of the pulp back to concentrated serum solids reconstitute in much the same way as those prepared by the direct drying procedure, provided the pulp is properly dispersed in the serum.

## VOLATILE FLAVORS

Only minor amounts of volatile flavor were obtained by steam distilling or stripping the volatile flavor components from various lots of commercial tomato pastes after reconstitution. This, of course, is not surprising, since the pastes have already been concentrated under vacuum and the volatile materials discarded. This small amount of volatile material found in samples of commercial paste seems to develop during storage but its return does not improve the taste or flavor of the reconstituted powder. Taste, flavor, and color of the reconstituted powders were quite similar to those of the corresponding reconstituted pastes.

Somewhat different results were obtained with single-strength canned tomato juice. In one experiment single-strength juice, paste prepared from this juice by vacuum concentration, and powder prepared from this paste were compared organoleptically by the triangular method of comparison. All samples were reconstituted to 6% solids. Reconstituted paste and powder were indistinguishable and the single-strength juice was significantly different from either the reconstituted paste or powder, presumably owing to removal of volatile flavor during concentration. Steam distillation or stripping at atmospheric pressure adversely changed the character of this volatile flavor so that it did not restore the original canned-juice flavor when added to the paste or powder. Later experiments showed that reconstituted tomato powder, when canned in bright tin plate and stored for several days at room temperature, developed a flavor similar to the original canned single-strength juice.

**TABLE 1**

**Composition and properties of powders prepared from commercial tomato pastes**

| Total solids | Titratable acidity (as citric) % dry basis | Suspended [1] pulp volume % | Anhydrouronic acid [2] % dry basis | | Aerated paste | | Bulk density g./ml. | Reconstitution of powder | | Specific [3] apparent viscosity |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Total | Soluble | Apparent density g./ml. | Mixing time (min.) | | Time min. | Consistency | |
| 38.6 | 5.2 | 25 | 3.2 | 2.5 | 1.01 | 1 | 0.29 | 3 | good | 1.6 |
| 37.6 | 5.6 | 25 | 3.3 | 2.6 | .... | .... | .... | .... | good | .... |
| 30.0 | 5.3 | 23 | 3.0 | 2.7 | 1.01 | 5 | 0.28 | 4 | good | 1.8 |
| 25.2 | 5.2 | 23 | 3.6 | 2.9 | 1.00 | 5 | 0.21 | 2 | good | 1.8 |
| 36.0 | 5.6 | 21 | 3.2 | 2.9 | 0.91 | 5 | 0.23 | 4 | good | 1.7 |
| 37.2 | 5.6 | 19 | 3.0 | 2.5 | 0.90 | 5 | 0.26 | 4 | good | 1.6 |
| 25.5 | 7.0 | 23 | 2.1 | 2.2 | 0.98 | 5 | 0.35 | 10 | acceptable | 1.5 |
| 26.1 | 7.7 | 24 | 2.8 | 2.7 | 0.93 | 5 | 0.26 | 4 | acceptable | 1.5 |
| 37.5 | 7.2 | 15 | 0.8 | 1.1 | 1.02 | 20 | 0.37 | 1000 | watery [4] | 1.3 |
| 40.2 | 7.2 | 15 | 1.5 | 1.1 | 1.04 | 20 | 0.46 | 1000 | watery [4] | 1.2 |
| 38.2 | 6.8 | 14 | 0.8 | 0.9 | 1.02 | 20 | 0.38 | 1000 | watery [4] | 1.2 |
| 38.0 | 6.1 | 17 | 4.0 | 2.1 | 0.95 | 20 | 0.34 | 1000 | watery [4] | 1.4 |
| 38.0 | 5.7 | 18 | 4.3 | 2.2 | 1.02 | 20 | 0.36 | 1000 | watery [4] | 1.4 |

[1] By centrifuge (16 in.), 2,000 r.p.m. for 30 minutes, reconstituted to 6% solids.
[2] Anhydrouronic acid x 1.4 is the approximate pectin content.
[3] Measured at 70° F. by rate of flow through orifice.
[4] Not completely reconstituted.

## EFFECT OF TEMPERATURE

A series of tomato powders was prepared from one lot of concentrated tomato juice by the direct-drying procedure to determine the maximum product temperature that is permissible if heat damage and off-flavors are to be avoided. Powders were prepared both with and without sodium bisulfite (0.05% as $SO_2$, dry basis), added prior to drying with a pressure of 1 mm. Hg. in the dryer. This amount of sodium bisulfite in the feed resulted in about 400 p.p.m. of $SO_2$ in the powder and was near the taste threshhold for even the most critical panel members, since the concentration of $SO_2$ in the reconstituted product was reduced to about 25 p.p.m. All samples were compared by triangular taste tests.

In samples dried without added $SO_2$, no evidence of heat damage was detected if product temperatures did not exceed 150° F. (65.6° C.). At 160° F. (71.1° C.) and above, definite off-flavors were present. In samples containing added sodium bisulfite no evidence of heat damage was found if the product temperature was allowed to reach 190° F. (87.8° C.). Drying times of about 2.5 hours were required to reduce the powder to 3% moisture if the maximum product temperature was 150° F. (65.6° C.). By raising the product temperature to 190° F. (87.8° C.) during the latter stages, the drying time was reduced to about one hour. Overdrying or irregularity in thickness of film of concentrate being dried results in heat damage to the product at these higher temperatures.

## ASCORBIC ACID RETENTION

There has been little evidence of ascorbic acid loss in any of the steps in converting concentrated tomato juice or tomato paste to a powder, either by direct drying or by the split-drying procedure. Table 2 shows ascorbic acid retention throughout the various steps in the direct drying process. Analyses were made for reductones that might be present in the paste or that might develop during drying. Reductones, equivalent to about 14% of the ascorbic acid, were found in the one lot of paste analyzed. There was no evidence of reductone formation during drying.

**TABLE 2**

**Ascorbic acid retention in converting concentrated tomato juice to a powder by direct drying procedure**

| | Ascorbic acid, mg./100 g. dry basis | |
|---|---|---|
| | Drying temperature, 150° F. | Drying temperature, 190° F. |
| Concentrated juice (before aeration) | 197 | 213 |
| Concentrated juice (after aeration) | 189 | 210 |
| Tomato powder | 197 | 228 |

## PACKAGING

Tomato juice powder is quite hygroscopic and must be handled in a room maintained at about 10% relative humidity after removal from the dryer. Since the powder is hygroscopic it must be packaged in a container with extremely low moisture-vapor permeability. Most samples have been packed with an in-package desiccant to reduce moisture content during storage *(11)*. However, with tomato-juice powder it is possible to reduce the moisture content of the $SO_2$-containing powder to about 1% through the use of high product temperatures without extending the drying time excessively or adversely affecting its flavor or color. Tomato powder with this low moisture content may be sufficiently stable in storage so that in-package desiccation will not be required.

## SUMMARY

Two vacuum drying procedures have been developed, on a laboratory scale, for the production of dehydrated tomato juice. In one, high-density paste is converted directly into a powder; the other utilizes a split-drying procedure in which the serum and pulp are dried separately and recombined. After reconstitution the tomato juice powder is indistinguishable by color, flavor, or consistency from the paste from which it was prepared. The powder reconstitutes rapidly in cold water.

During drying the product temperature should not exceed 150° F. (65.6° C.) if heat damage is to be avoided. Addition of small amounts of sodium bisulfite raised the maximum permissible drying temperature to 190° F. (87.8° C.). With batch-type drying equipment, concentrate with added sodium bisulfite can be dehydrated in about one hour. Without sodium bisulfite, about 2.5 hours are required.

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# Factors Influencing the Mold Count of Raspberries[a]

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(Manuscript received July 28, 1954)

**It is shown that the length and temperature of storage are factors of great importance in determining the mold count of berries entering the processing line. Intervals between picking have little influence on the mold in freshly picked berries. Rainfall preceding picking influences the count on freshly picked berries markedly.**

During the past few years the Food and Drug Administration has seized many shipments of canned and frozen black raspberries because of their high mold count *(5)*. Fabian *et al. (2, 3, 4)* estimated that such seizures reduced the pack one-third in Michigan in 1950, with considerable loss to industry and to the consumer. They considered that the administrative tolerance of 40 positive fields used by the FDA was too severe and studied the problem from that standpoint. They reported that ripe berries usually contain mold even when freshly picked and the amount of mold was higher in humid than in dry weather. The length of time between picking and processing was found to be an important factor influencing the mold count.

Needham and Fellers *(7)* had recommended earlier that raspberries be held for not more than a day under ordinary cannery conditions. Narasimham *et al. (6)*, studying effect of harvesting conditions on the mold count of black raspberries, observed that the count of shiny berries was always low, while that of soft berries was high. They obtained lower mold counts from the berries in a planting by shaking the bushes to remove the soft fruit.

The importance of this problem suggested a study in New York State to determine how mold counts may be affected by weather conditions, time and temperature of storage, and processing methods.

## EXPERIMENTAL METHODS

Raspberry samples were obtained from 6 processing plants in western New York and from plantings at this Station during the 1952 and 1953 seasons. All mold counts were run using the Howard method and a 1:1 dilution of berries, Steinkraus, Copeland, and Pederson *(8)*. Canned samples were drained of juice before pulping and counts were run with and without the juice.

Mold counts were run on daily pickings of red and black raspberries from Station plantings. Complete records of daily temperature and rainfall were available at the local weather station. An effort was made to determine what effect changes in weather conditions, particularly rainfall, had on the mold content of the freshly picked berries.

The Station plantings were divided into sections which were picked at 1, 2, 3, 4, 7, and 10-day intervals in order to determine whether this factor influenced the mold content of freshly picked berries.

Berries were checked at 3 points in the commercial processing plants (a) entering processing line (b) after washing and sorting and (c) after canning. Heat-processed samples were taken from the cans in which they had been packed. All other samples were either counted immediately or were quick frozen.

In order to demonstrate the importance of holding time and temperature on the mold count of berries, 62 samples of freshly picked red and black raspberries were stored in replicate at 7° and 21° C. respectively for varying lengths of time. Mold counts were run at the beginning and at intervals during storage.

## RESULTS AND DISCUSSION

Mold counts of fresh red raspberries were consistently lower than those of fresh black raspberries. Mold counts of berries picked from Station plantings and counted immediately were generally lower than those on industrial berries which normally had been held for varying periods of time after picking.

**Weather influence.** A most important factor determining the amount of mold in black raspberries was the amount of rainfall occurring during the picking season. This effect was observed both years and is illustrated for the 1953 season in Figure 1. During the first half of July there was very little rain and mold counts remained low. In the last half of July, however, there was considerable rainfall and the mold counts of the freshly picked black raspberries tended to rise, particularly the day of or the succeeding day or two following the rainfall. Red raspberries did not reflect increases in rainfall with increase in mold count as definitely as did black raspberries.

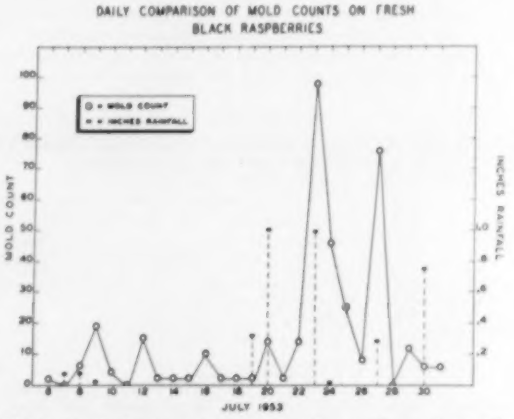


**Figure 1. Daily comparison of mold counts on fresh black raspberries.**

**Intervals between picking.** There was as great or greater a variation in the mold counts of berries picked daily as in the counts of berries picked at longer intervals. It was concluded that, in general, environmental factors such as rainfall and humidity during the growing period are of greater importance than the interval between pickings. Possibly one reason why the longer intervals between pickings do not result in an increase

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in mold count is that the ripe berries fall off the bushes if not picked within a reasonable time and thus fail to add whatever mold they contain. Results with red raspberries were similar.

**Effect of processing procedures.** Present washing and sorting procedures within the processing plant are not as effective in lowering mold counts as would be desirable. Daily comparison of mold counts on the fresh and processed (washed and sorted) berries at 2 plants revealed that the counts on the berries before and after processing followed each other very closely (Figure 2).

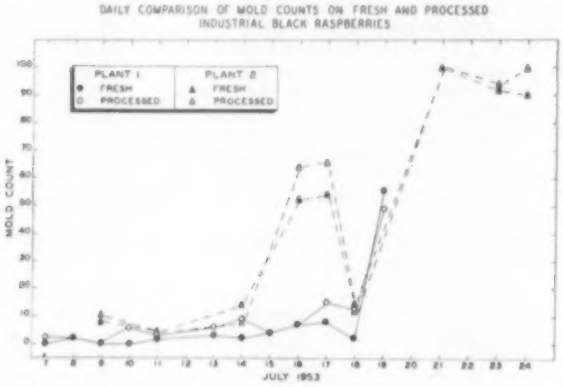


**Figure 2. Daily comparison of mold counts on fresh and processed industrial black raspberries.**

On days when the mold content of incoming berries was high, the count of the processed berries remained high.

When similar line-run studies were carried out and the canned raspberries were included, similar results were obtained if the mold counts were run on the canned berries after draining the syrup (Table 1).

Addition of syrup constitutes approximately a 50% dilution which was reflected in a lower mold count as might have been forecast by previous work of the authors *(8)*.

**Increase in mold count during storage prior to processing.** As indicated above, rainfall determines to a large extent the amount of mold present in the freshly picked berries. Under ideal conditions, these freshly picked berries would be processed immediately and no further increases in mold count would occur. In practice, however, some delay occurs between picking and processing. In most cases the berries are kept at warm summer temperatures during the entire period after picking until entering processing lines.

During this period mold counts will naturally rise. For example, 22 samples of superior quality freshly picked black raspberries with an average mold count of 5 were stored in replicate at 21° C. After 24 hours the average count had increased to 23, or 360%. On a theoretical basis, a sample having an initial count of 22 would yield a count of 100% positive fields after 24 hours at 21° C. Indeed, one of the samples tested did have a count of 20 at the start. After 24 hours at 21° C. the count had risen to 90.

Ten samples stored in replicate at 7° C. and having an initial average mold count of 5, yielded an average count of 12 at the end of 24 hours. The rate of increase at 7° C. was less than half that occurring at 21° C.

Molds grew more slowly in red than in black raspberries.

**TABLE 1**

**Comparison of mold counts on line-run samples of raspberries**

| Run no. | Fresh unsorted | Washed sorted | Canned | |
|---|---|---|---|---|
| | | | Berries and juice | Berries only |
| 1 | 90 | 94 | 13 | 40 |
| 2 | 96 | 30 | 41 | 80 |
| 3 | 12 | 27 | 8 | 16 |
| 4 | 6 | 18 | 0 | 0 |

## SUMMARY

Mold counts run on 473 samples of fresh raspberries over the 1952 and 1953 seasons were low and fairly comparable. Rain preceding picking appeared to be most important in determining the count of freshly picked berries. The interval between pickings was found to have little influence on the mold in the freshly picked berries. The initial mold counts and the length and temperature of storage were the factors determining the mold count of berries entering the plant processing lines.

Present commercial methods of washing and sorting were not as effective in lowering mold count as would be desirable. Lower mold counts on canned berries appeared to be due to dilution with syrup rather than to effective sorting procedures preceding canning.

### Acknowledgment

The authors acknowledge their indebtedness to Mrs. Margaret Albury for technical assistance during the summers of 1952 and 1953, to Professors George Slate and Robert Lamb for reserving sections of the New York State Agricultural Experiment Station berry plantings for use in this study, and to members of the New York State Canners and Freezers Association who furnished samples of berries.

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# Bacterial Spoilage of Shell Eggs. I. Bacteriology

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(Manuscript received July 30, 1954)

**The significance of fluorescent and non-fluorescent bacteria in the spoilage of fresh, shell eggs from farms in British Columbia has been investigated. Although all bacteria were Gram negative, a considerable proportion were non-fluorescent. In a survey involving 4,821 eggs, 4.9% were found to be potentially spoilable by bacteria, and 18.5% of the spoiled eggs were infected only with non-fluorescent forms. The efficacy of ultra-violet light for detection of bacterial spoilage has been studied. Infection of the eggs was found to occur during wet-washing of eggs, by soiling and by nesting materials.**

Bacterial spoilage of shell eggs has resulted at times in serious economic losses, and a number of bacteriological studies have been made of the problem. The literature on the bacterial spoilage of eggs has been reviewed in a recent publication by Lorenz and Starr *(6)*, and Winter and co-workers *(9)* have summarized the investigations into the effect of washing on the bacterial infection in eggs. Most of these studies have been made either on eggs that have been held in cold storage or on eggs that have been produced and handled under controlled conditions. In contrast, the investigations reported here used fresh eggs arriving from randomly selected farms and held in storage just long enough for any latent spoilage to develop. Thus, the results should reveal the character of bacterial spoilage of eggs as delivered to market.

Previous work has placed considerable emphasis on pseudomonads as the cause of the spoilage. These pseudomonads are characterized by the production of fluorescin which, when viewed under long-wave ultra-violet light ("black-light"), produces a greenish or blue-green fluorescence. As a result, "black-light" candling has been relied upon for the detection of infected eggs by many commercial receiving stations. In the present work attention was therefore first directed to the bacteriology of spoiled eggs and to the value of black-light candling for their detection.

Fresh eggs were obtained at commercial receiving stations immediately following their collection from farms in the lower Fraser Valley of British Columbia. Only white shelled eggs were used. The number of fluorescent eggs available for study was limited because most of the work was done during the late fall and winter when the incidence of fluorescence apparently dropped and because only one local grading station was using black-light candling when this work was initiated.

## METHODS

Two models, No. 301 and No. 301 A, of "Vogelite," long-wave ultra-violet, candling lamps were used in the examination of intact eggs. All candling was done with one or other of these lamps by professional candlers from a commercial egg grading station. Opened eggs were examined for fluorescence using a Gates "Raymaster" multi-ray lamp with a long-wave ultra-violet tube (Type TS8) with an energy peak close to 3,600 Angstroms.

The following media were used for bacterial studies: (a) Difco nutrient agar; (b) selective medium for pseudomonas bacteria [Norris *et al. (8)*]: $K_2HPO_4$, 0.3%; $NH_4HPO_4$ 0.3%; $FeSO_4 \cdot H_2O$, 0.00005%; $MgSO_4$, 0.1%; glucose, 0.5%; agar, 1.5%. pH 7.2. In some of the later work streptomycin (Merck), in a concentration of 10 micrograms per ml., was included to make the medium more selective for fluorescent bacteria. This medium does not fluoresce under ultra-violet light; (c) medium for fluorescin production by pseudomonas bacteria [King *et al. (5)*]: ammonium succinate, 0.03%; glycerol, 1.0%; $FeCl_3$, 0.05 p.p.m.; $MgCl_2$, 0.01%; $K_2HPO_4$, 0.06% and $K_2SO_4$, 0.005%. pH 7.2. This medium likewise does not fluoresce under ultra-violet light.

The following method was developed and tested for the aseptic removal of egg contents from the shells:

> Both ends of the egg were treated with 2% iodine solution. Three small holes were drilled with a No. 56 drill (using a drill press) at the center of the pointed end of the egg and one hole in the center of the blunt end. The 3 holes were about 5/16 inches apart forming the corners of a triangle. All holes penetrated the shell but not the underlying membrane. The triangular portion of shell between the 3 holes at the pointed end of the egg was removed by means of sterile forceps and the exposed membrane at both ends of the egg was pierced with a sterile needle. Sterile air under pressure was introduced at the single hole at the blunt end of the egg, and the contents forced out at the pointed end of the egg which was held downward over a sterile receptacle, in which the contents were received.

## EXPERIMENTAL

**Efficacy of commercial black-light candling in the detection of fluorescent eggs.** A number of uncracked fresh eggs, classified as fluorescent by a commercial egg grading station, were examined for fluorescence of the albumen (opened egg), odour, bacterial content and presence of fluorescent bacteria. The eggs used in this test were not older than 10 days. The eggs were opened aseptically as previously described and total bacterial numbers determined by plating on nutrient agar. The presence of fluorescent bacteria was determined by streaking the eggs or plating dilutions of them on the selective pseudomonas medium and then examining the plates under the Gates lamp after the colonies had appeared.

As shown in Table 1, of 27 eggs classified as fluorescent by commercial whole egg candling, only 3 had fluorescent albumen. From the eggs with fluorescent albumen, fluorescent bacteria were isolated by plating methods, whereas from eggs whose albumen did not fluoresce, no fluorescent bacteria were obtained. All eggs that exhibited a bad odour contained bacteria, although some eggs that did not smell bad also contained bacteria. Of the 18 eggs examined bacteriologically, only half contained bacteria, and of these, only 3 contained fluorescent bacteria. The eggs which were sterile appeared perfectly good on the basis of odour, texture, and colour.

In the black-light candling of eggs as done locally, the eggs are candled once, within 2 days of arrival at the grading stations. The possibility therefore existed that potentially fluorescent eggs might be missed if the commercial candling was done before adequate amounts of fluorescin were formed. To check this, arrangements were made with a commercial grading station to recandle a batch of washed, dirty eggs from a supplier whose shipments were known to contain fluorescent eggs. One hundred and eighty eggs were candled immediately after arrival at the

**TABLE 1**

**Examination of eggs commercially graded as fluorescent**

| Egg No. | Fluorescence | | | Total bacteria/ml. | Fluorescent bacteria |
|---|---|---|---|---|---|
| | Whole egg [1] | Albumen | Odour | | |
| 1 | + | — | — | 400 | — |
| 2 | + | — | — | 0 | — |
| 3 | + | + | ++++ | 2,180,000,000 | + |
| 4 | + | — | — | 0 | — |
| 5 | + | — | — | 621,000 | — |
| 6 | + | — | — | 0 | — |
| 7 | + | — | — | 208,000,000 | — |
| 8 | + | — | — | 0 | — |
| 9 | + | — | — | 0 | — |
| 10 | + | — | — | 0 | — |
| 11 | + | — | — | 100 | — |
| 12 | + | + | ++++ | 222,000,000 | + |
| 13 | + | — | — | 0 | — |
| 14 | + | — | — | 0 | — |
| 15 | + | — | — | 0 | — |
| 16 | + | — | ++++ | 1,380,000,000 | |
| 17 | + | + | ++++ | 24,000,000,000 | — |
| 18 | + | — | ++++ | 2,000,000,000 | + |
| 19 | + | — | — | Not determined | — |
| 20 | + | — | — | Not determined | |
| 21 | + | — | — | Not determined | |
| 22 | + | — | — | Not determined | |
| 23 | + | — | — | Not determined | |
| 24 | + | — | — | Not determined | |
| 25 | + | — | — | Not determined | |
| 26 | + | — | — | Not determined | |
| 27 | + | — | — | Not determined | |

[1] Fluorescence examination of whole eggs done at a commercial grading station.

grading station when they were 2 to 9 days old, and again after 8, 15, and 26 days, using a Vogelite lamp, Model 301.

The relation between age of eggs and fluorescence as indicated by this lamp is shown in Table 2. On the first candling, 6 fluorescent eggs were found; 8 days later 18 more fluorescent eggs were isolated; at 15 days, 27 more eggs; and after 26 days, 40 more eggs. Thus, although only 3.3% of the eggs were found fluorescent at the first candling, 50.5% of the eggs were classified as fluorescent after 26 days. These results show that potentially fluorescent eggs cannot be separated from freshly laid eggs using the fluorescence phenomenon because of the varying rates of development of fluorescence in infected eggs. Despite its limitations for commercial practice, the black-light was accepted as a useful research tool and used extensively in carrying out many parts of these investigations.

**TABLE 2**

**Periodic recandling of washed, dirty eggs using long-wave ultra-violet light**

| Time (days) | No. Fluorescent | % Fluorescent (based on 180 eggs) |
|---|---|---|
| 0 | 6 | 3.3 |
| 8 | 18 | 10.0 |
| 15 | 27 | 15.0 |
| 26 | 40 | 22.2 |
| Total | 91 | 50.5 |

**TABLE 3**

**Bacteriological examination of spoiled eggs**

| Lot | No. Eggs | Type of Infecting Bacteria | | |
|---|---|---|---|---|
| | | Fluorescent | Non-Fluorescent | Mixed |
| A | 4 | 0 | 3 | 1 |
| B | 5 | 0 | 3 | 2 |
| C | 12 | 1 | 1 | 10 |
| D | 16 | 0 | 3 | 13 |
| Totals | 37 | 1 (3%) | 10 (27%) | 26 (70%) |

**Microbiology of infected eggs.** As shown in Table 1, many eggs that were classified as fluorescent by commercial candling with long-wave ultra-violet light did not have fluorescent albumen or contain fluorescent bacteria. Since attention in California has centered on a fluorescent, pseudomonas-type of infection *(7)*, the significance of fluorescent bacteria in the spoilage of local eggs was studied in detail. Four lots of uncracked eggs, totalling 49 eggs, that had been classified as fluorescent by a commercial grading station, were examined bacteriologically. After aseptic removal of the eggs from the shells dilutions of the eggs were plated on nutrient agar and on the pseudomonas selective medium. Colonies growing on the latter medium were examined under the Gates lamp to determine the presence of fluorescent colonies. Of the 49 eggs examined, 12 (24%) were found to be sterile. The data on the spoiled eggs are presented in Table 3. One contained only fluorescent bacteria, 10 (27%) contained only non-fluorescent bacteria and 26 (70%) contained both fluorescent and non-fluorescent bacteria.

Examination was then made into the relative numbers of fluorescent and non-fluorescent bacteria occurring in eggs stored for not more than 30 days at 15° C. (60° F.). The contents from eggs classified as fluorescent by commercial candling with a Vogelite lamp, Model 301, were serially diluted and platings were made on both nutrient agar and on pseudomonas selective agar. After incubation at 25° C. for 48 hours, total counts were obtained from the nutrient agar plates, and the numbers of fluorescent organisms determined from the pseudomonas agar plates using the Gates lamp. The data on the infected eggs are assembled in Table 4.

**TABLE 4**

**Percentage of fluorescent bacteria in commercially graded fluorescent eggs**

| Egg. No. | Total Bacteria/g. | Fluorescent Bacteria/g. | % Fluorescent Bacteria / Total Bacteria |
|---|---|---|---|
| 1 | 100 | 0 | 0 |
| 2 | 222,000,000 | 62,000,000 | 28 |
| 3 | 1,380,000,000 | 0 | 0 |
| 4 | 24,000,000,000 | 2,710,000,000 | 11 |
| 5 | 2,000,000,000 | 0 | 0 |
| 6 | 339,000,000 | 0 | 0 |
| 7 | 373,000,000 | 11,600,000 | 3 |
| 8 | 44,000,000 | 51,200,000 | 115 |
| 9 | 490,000,000 | 146,000,000 | 30 |
| 10 | 48,300,000,000 | 25,000,000,000 | 53 |
| 11 | 29,225,000 | 0 | 0 |
| 12 | 111,000,000 | 2,800,000 | 3 |
| 13 | 82,000,000,000 | 200,000,000 | 0.5 |
| 14 | 48,000,000 | 0 | 0 |
| 15 | 27,500,000,000 | 423,000,000 | 2 |
| 16 | 1,215,000,000 | 110,000,000 | 10 |

In Table 4 the percent of the total bacterial population in each egg which was fluorescent is indicated in the extreme right-hand column. These percentage values are only approximate because identical growth of bacterial isolates on two different substrates is not possible. However, the values do indicate that non-fluorescent bacteria occurred in greater numbers than fluorescent bacteria in the eggs examined. Among the 16 infected eggs, 9 contained both fluorescent and non-fluorescent bacteria, 6 contained only non-fluorescent bacteria, and one contained only fluorescent bacteria.

The results of Tables 3 and 4 taken together show that fluorescent bacteria in commercially rejected eggs constitute a significant, but generally minor segment of the total bacterial population. Although fluorescent bacteria are probably responsible for the occurrence of true "fluorescent" eggs, the local egg spoilage problem had to be considered as arising from a more general bacterial infection. In all cases only Gram negative rods have been found.

**Artificial infection of eggs with fluorescent and non-fluorescent isolates.** During these studies many organisms were isolated in pure culture from spoiled eggs. These isolates were classified as fluorescent or non-fluorescent on the basis of exami-

nation under the Gates lamp when grown on pseudomonas agar. As a further check, all isolates were inoculated into the liquid medium of King *et al. (5)*, which is ideally suited for fluorescin production by pseudomonas organisms. It was found that the original grouping of all these organisms had been correct.

To determine whether or not fluorescent and non-fluorescent organisms could pass through the shells of fresh eggs and cause spoilage, 12 eggs were infected with 12 different fluorescent isolates and a similar number with 12 non-fluorescent isolates according to the method of Haines and Moran as described by Lorenz *et al. (7)*. As some modifications were made, the method is described briefly:

> Non-fluorescent isolates in pure culture were grown in nutrient broth for 48 hours, centrifuged and resuspended in cold (5° C.) water to a volume of 30 ml. Fluorescent isolates were treated similarly except the pseudomonas medium was used for propagation. Unwashed, nest-clean, white eggs from the University of British Columbia Farm were warmed to 36° C. in an incubator for 18 hours, immediately placed in individual sterile 50 ml. beakers, and the individual suspension of each isolate poured over a warm egg until the egg was completely submerged. The eggs were left in contact with the aqueous suspensions for exactly five minutes, the suspensions drained away, and the eggs dried immediately on sterile metal trays in an oven of 36° C. The eggs were then placed on clean trays and incubated. Twelve eggs were reserved as controls.

The eggs were tested with a Vogelite lamp after 38 days incubation at 15° C. and the abnormal eggs removed and examined bacteriologically. The remaining eggs were held at 25° C. until 55 days and then examined bacteriologically. One which had been treated with non-fluorescent bacteria was discarded from the test because of cracks.

Of 12 eggs treated with suspensions of fluorescent bacteria, 9 became infected and exhibited typical green fluorescence when candled under the Gates lamp. Pure cultures were isolated from all infected eggs and each culture corresponded microscopically to the organisms used for infection.

That passage through the shell and subsequent spoilage of the egg is not restricted to fluorescent bacteria was shown by the successful infection of 5 of 11 eggs by pure cultures of non-fluorescent bacteria. The albumens of these infected eggs did not exhibit green fluorescence under the Gates lamp. From all these infected eggs, bacteria were obtained in pure culture and the bacteria from each egg resembled microscopically the corresponding organism with which the egg had been infected. The control eggs were sterile.

By the foregoing series of tests it has been demonstrated that both fluorescent and non-fluorescent organisms may be isolated from spoiled eggs, and that these organisms, in pure cultures, may be made to penetrate and infect fresh, clean eggs and cause spoilage.

**Cause of infection of eggs.** Five local egg companies were asked to designate farms from which a greater than average number of infected eggs had been received. Nine shippers of eggs were selected for study (farms A to I, inclusive). From each farm, except "A" and "C," were obtained 10 dozen unwashed, heavy dirty eggs, 10 dozen washed eggs and 10 dozen nest-clean eggs (unwashed). From farm "A," the numbers of eggs were 45, 45 and 90 dozen in groups respectively, and from farm "C," 9 dozen in each group.

After receipt from the farm, all eggs were stored for from 4 to 7 weeks at 15° C. ± 2 and at a relative humidity of 50-75%. The eggs were then candled by a professional candler using a Vogelite lamp, Model 301A. Cracked eggs were discarded, and uncracked eggs were classed as fluorescent rots, non-fluorescent rots, or rot-free. All eggs showing rot by candling were broken out into dishes and regraded as fluorescent or non-fluorescent by inspection under the Gates lamp. It has been found that the latter method is more reliable for detecting fluorescence than is whole egg candling. From 5,001 eggs, 180 cracks were removed, leaving 4,821 eggs for the experiment.

Out of 4,821 uncracked eggs, 238 or 4.9% were infected. Of 238 infected eggs, 44 or 18.5%, did not exhibit fluorescence. It would be expected that many of the 194 eggs that showed fluorescent spoilage contained both fluorescent and non-fluorescent organisms. The data confirmed earlier observations that both fluorescent and non-fluorescent bacterial spoilage are involved in egg deterioration locally.

A true comparison between dirty, washed, and nest-clean eggs, and between eggs from the different farms, must be based on percentage values since the numbers of eggs in the various groups differ. Table 5 presents the rots (fluorescent and non-fluorescent combined) expressed as percentage of the total number of eggs tested for each group.

**TABLE 5**

**Percentage of rots in unwashed dirty eggs, washed eggs and nest clean eggs from nine farms**

| Farm | No. Eggs | Percentage of Spoiled Eggs | | |
|---|---|---|---|---|
| | | Unwashed Dirty | Washed | Nest-clean |
| A | 2,066 | 0.4 | 25.7 | 4.0 |
| B | 340 | 4.7 | 5.1 | 0.0 |
| C | 318 | 7.6 | 5.6 | 1.9 |
| D | 350 | 0.0 | 14.5 | 0.9 |
| E | 340 | 0.9 | 6.0 | 0.0 |
| F | 355 | 0.9 | 0.0 | 0.8 |
| G | 347 | 0.0 | 0.0 | 0.0 |
| H | 355 | 0.0 | 0.0 | 0.0 |
| I | 350 | 0.0 | 0.0 | 0.0 |

Of the 9 farms in the test, 5 (Farms "A" to "E," inclusive), produced a significant proportion of spoiled eggs. Washed eggs showed the greatest amount of infection and spoilage ranged between 5.1 and 25.7%. Significant infection was also found among unwashed dirty eggs from 2 farms (4.7 and 7.6%), and from the nest-clean eggs from 2 farms (1.9 and 4.0%).

Washing appeared to be the commonest cause of infection, dirty eggs next in importance, followed by infection at the nest.

## DISCUSSION

Long-wave, ultra-violet light is extremely useful for investigating the fluorescence of opened eggs, but its limited accuracy in the detection of bacterial infection of whole eggs makes its general commercial application unreliable.

Besides giving false positives, it has two additional and more serious short-comings. In the first place, these studies on local fresh eggs have shown that 18.5% of the spoiled eggs did not fluoresce and therefore fluorescence can not be used to detect spoilage of this type. Secondly, and this is even more serious, the spoilage is often not sufficiently advanced to be apparent by fluorescence at the time the eggs are candled. Lorenz *et al. (7)* have shown that the number of fluorescent eggs detectable by intact egg candling will increase over a period of weeks. Their results are confirmed here. Therefore it is more important to remove the means of infection than to improve black-light diagnostic techniques.

Both fluorescent and non-fluorescent organisms lead to spoilage of eggs produced locally. Not only have organisms of these two types been isolated from spoiled eggs, but pure cultures of each type have been used to infect fresh clean eggs and to cause spoilage of these eggs. That non-fluorescent organisms, as well as the fluorescent organisms, should cause spoilage is not at all surprising. Haines *(4)* has listed a number of species capable of infecting and causing spoilage of eggs, and Alford *et al. (1)*, in studying the egg spoilage problem in Australia, also found both fluorescent and non-fluorescent organisms to be important. Although con-

siderable emphasis has been placed on the pseudomonas group in recent studies in the United States, the work of Forsythe *et al. (3)*, shows that non-fluorescent organisms are also involved in the egg spoilage problem in that country. In the trade, there has been an unfortunate tendency to exaggerate the importance of the fluorescent type of egg spoilage and to minimize or overlook the non-fluorescent types.

The greatest amount of infection has been found to occur in wet-washed eggs. There is considerable controversy in the literature as to whether or not washing of eggs is a source of infection. Winter *et al. (9)* give a very complete review of the investigations supporting both sides of this argument. Inconsistencies in results of different investigators can be largely explained by the fact that results depend on how the eggs are washed. The investigators who have found little or no infection of washed eggs have carried out the washing under strictly controlled conditions which would not be realized on most farms. Whether it will be practical in the long run to condone the washing of eggs on farms will depend upon the percentage of farmers whose wet-cleaning methods produce infection, and upon whether or not these farmers can be educated into using more satisfactory wet-cleaning methods. If further study of this problem shows that infection through the wet-cleaning of eggs is extremely widespread, then it may be desirable to reduce the market value of washed eggs to discourage this practice.

The infection of heavily soiled eggs by bacteria introduces a more difficult problem than infection through the washing of eggs. The only really effective way to avoid this infection is to reduce or eliminate the production of heavy dirty eggs on farms, or have receiving stations refuse to accept them. The first course would call for more sanitary farm management practices, particularly in the construction of chicken houses and in the use of clean nests. This answer would be ideal as it would also reduce or eliminate the cleaning operation, as well as reduce the possibility of infection by nesting material. If the receiving station would accept only nest-clean or cleaned, light-dirty eggs, farmers would have to improve their operations so that mainly clean eggs were produced.

According to Berven *(2)*, the Poultry Producers of Central California have been able to increase unwashed eggs coming to their plants from 50% in 1951 to 88% in 1953 by devaluing washed eggs. Flood black-lighting is used for determining whether or not eggs have been washed. Unless some simple, reliable method is found by which eggs can be given a simple, quick sterilization treatment shortly after being laid, it may be necessary to insist that all eggs coming from farms be clean-as-laid. This is a drastic demand to make of the egg producers, and it could only be justified if shown to be necessary by further investigations.

## SUMMARY

Gram-negative bacteria were found to be the cause of egg spoilage.

Spoiled eggs contained both non-fluorescent and fluorescent types of bacteria, with non-fluorescent types predominating.

It has been possible to infect fresh eggs with both non-fluorescent and fluorescent bacteria isolated from spoiled eggs. Thus both types of bacteria can cause eggs to spoil.

Commercial candling with ultra-violet lamps is only partially effective in detecting infected eggs.

In a survey of nine farms, bacterially spoiled eggs were obtained from five farms, and the potential spoilage was 4.9% of all eggs.

In order of importance, the causes of infection in eggs on farms were poor washing methods, heavy visible soiling of eggs, and infection of eggs by nesting material.

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# Bacterial Spoilage of Shell Eggs. II. Incidence of Spoilage in Eggs from Ninety-four Farms

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**A survey of eggs from 94 farms located in the Fraser Valley area of British Columbia has shown that about 70% of the farms are submitting eggs to market that are infected with spoilage bacteria to the extent of 1% or more. This level of spoilage is probably no higher than would be found by a similar large sampling of eggs from other producing areas and it is merely fortuitous that many of the eggs are not in a spoiled condition when they reach the consumer. Corrective measures for controlling bacterial spoilage of eggs must be applied to the egg producing area as a whole and not to specific farms. The present methods of wet-cleaning of eggs, both manual and mechanical, are mainly responsible for infection. Although mechanically washed eggs from some farms were free from infection, in general they were more likely to be infected than eggs cleaned in other ways. Eggs from New Hampshires are less susceptible to bacterial spoilage than eggs from Leghorns and cross-breeds because wet-washing of eggs from New Hampshires does not increase the bacterial spoilage significantly.**

A previous investigation of eggs from nine farms in an egg-producing community revealed bacterially spoiled eggs in shipments from five of the farms and bacterial spoilage of 4.9% of 4,821 eggs tested *(11)*. The selection of the nine farms was, however, based on unfavourable reports from egg-grading stations and therefore the results were not representative of the farming area as a whole. Before considering methods for controlling the infection of eggs, it was necessary to determine whether the infection was concentrated in a small number of farms, or was of general incidence. In the first case, the problem could be solved through a detailed study of the few farms producing spoiled eggs; if the second situation obtained, then a solution to the problem would have to take into consideration egg producing and egg handling practices as generally applied on the farms.

The Fraser Valley area of British Columbia was chosen for these studies. This farming area accounts for about 80% of the eggs produced in the Province, and has an annual production of 350,000 cases of market eggs. Originally it was planned to study the eggs from 100 randomly selected farms; actually eggs were obtained from 94 farms. Records were taken on the management practices and sanitation of each farm with the object of gaining information that might be of value in ascertaining the causes of infection of eggs by spoilage bacteria.

## METHODS

From June 15 to June 25, 1953, 15 dozen eggs were collected from each of 94 farms randomly selected from an area of 600 square miles. The collections were carried out through the generous cooperation of local feed companies and their field representatives. The eggs were representative of the product normally going to market, except that heavy-dirty eggs, either cleaned or uncleaned, were excluded. For this work, a heavy-dirty egg was defined as one having a dirt area on the shell greater than the area of a thumb nail. To avoid bias, the eggs were not packed into the shipping cartons beforehand by the farmer, but collected and placed into clean flats and trays by the field men when visiting a farm. A detailed report on egg handling practices and general sanitation was completed for each farm at the time of the collection of eggs.

The groups of 15 dozen eggs from each farm were contained in individual cartons and transported from the farms to the laboratory within a 24-hour period. To accelerate any latent bacterial spoilage, the eggs were stored in a thermostatically controlled room at 60° F. (15° C.) for a period of 6 to 7 weeks before examination for spoilage. A "black-light" candling lamp (Vogelite, Model 301A) was used in the examination of the eggs. White shelled eggs were candled in the intact condition and those appearing abnormal were subsequently broken out and recandled to make certain of the infection. All brown and tinted eggs were broken out separately before examination under the black-light. Since the shells of the majority of eggs were colored, over two-thirds of the sound eggs were broken out before candling. The rotten eggs from each farm were segregated into those fluorescing under black light, and those not fluorescing.

## EXPERIMENTAL

**Incidence of spoilage in eggs from 94 farms.** Of 16,860 eggs received, 208 were cracked, leaving a balance of 16,652 eggs on which the studies were based. The percent spoilage ranged from zero on 6 farms to 25.8% on the farm with the most spoilage. In all, 532 eggs were found to be spoiled, 153 non-fluorescent rots and 379 fluorescent rots, giving an overall spoilage of 3.19% for all the uncracked eggs.

In Table 1 the farms are arranged in groups according to the percentage of eggs spoiled. Grouping the farms in this manner shows that 29 farms (31%) produced eggs with a spoilage of less than 1%. The eggs from these farms would probably be satisfactory commercially because conditions for development of spoilage organisms in commercial operation would be less favourable than those used in these tests. In the eggs from 65 farms (69% of the farms) the spoilage exceeded 1% and these farms must be regarded as potential sources of spoiled eggs in trade channels.

**Occurrence of fluorescent and non-fluorescent spoilage.** As indicated in Table 1, 153 out of 532 rotten eggs were non-fluorescent. Non-fluorescent organisms by themselves thus accounted for 28.8% of the rotten eggs. The rest of the rotten eggs, although appearing fluorescent under black-light, must not be considered exclusively fluorescent type spoilage because

**TABLE 1**
**Bacterial spoilage in eggs from 94 farms**

| Percent spoilage | Number of farms | Percent of farms | Number of eggs | Spoiled eggs | | |
|---|---|---|---|---|---|---|
| | | | | Non-Fluorescent | Fluorescent | Total |
| 0 | 6 | 6 | 1,070 | 0 | 0 | 0 |
| 0.6 | 23 | 25 | 4,104 | 11 | 12 | 23 |
| 1.0– 1.9 | 24 | 26 | 4,280 | 30 | 25 | 55 |
| 2.0– 4.9 | 20 | 21 | 3,565 | 28 | 77 | 105 |
| 5.0– 9.9 | 14 | 15 | 2,447 | 49 | 121 | 170 |
| 10.0–14.9 | 4 | 4 | 657 | 13 | 62 | 75 |
| 15.0–19.9 | 2 | 2 | 351 | 18 | 40 | 58 |
| 20.0–30.0 | 1 | 1 | 178 | 4 | 42 | 46 |
| Totals | 94 | 100 | 16,652 | 153 | 379 | 532 |
| Spoilage, Percent of Total Eggs | | | | 0.92 | 2.27 | 3.19 |

many of these eggs must have been infected with both non-fluorescent and fluorescent organisms, as was shown in previous studies *(11)*. In the work reported here, no attempt was made to segregate eggs spoiled by mixtures of non-fluorescent and fluorescent bacteria from those spoiled exclusively by fluorescent bacteria; if an egg appeared fluorescent under black-light, it was designated as fluorescent-spoiled.

To determine whether or not non-fluorescent spoilage of eggs occurred mainly on some farms and fluorescent spoilage on others, the farms have been grouped in Table 2 into those having

**TABLE 2**

**Distribution of non-fluorescent and fluorescent spoilage amongst 94 farms**

| Type of spoilage in eggs | Percent of farms |
|---|---|
| None | 6.3 |
| Non-Fluorescent only | 18.1 |
| Fluorescent only | 25.6 |
| Mixed—Non-Fluorescent and Fluorescent | 50.0 |
| Total | 100.0 |

only non-fluorescent spoilage, and those having both types. Inspection of the results of this table shows that 50% of the farms producing spoiled eggs have both non-fluorescent and fluorescent types of spoilage, that 25.6% of the farms have only fluorescent spoilage and 18.1% of the farms, only non-fluorescent spoilage. Since many of the individual eggs which appeared fluorescent must have contained both fluorescent and non-fluorescent bacteria, the higher percentage of the farms showing fluorescent spoilage compared to those showing only non-fluorescent spoilage is an apparent condition predetermined by the test rather than an actual condition. Thus, without undertaking a bacteriological analysis of all individual fluorescent eggs for non-fluorescent bacteria, the conclusion seems juistified that non-fluorescent and fluorescent types of spoilage occurred with random distribution amongst farms in the area under study.

**Comparison of the incidence of spoilage in farms using dry-cleaning and wet-washing of eggs.** Of the 94 farms submitting eggs for study, 37 farms employed dry methods for cleaning of eggs and 57 farms wet-washing methods. In Table 3, percentage of spoilage in eggs from these 2 farm groups is

**TABLE 3**

**Grouping of dry-cleaning and wet-washing farms on basis of egg spoilage**

| Level of percent spoilage | Percent of dry-cleaning farms (Total 37) | | Percent of wet-washing farms (Total 57) | |
|---|---|---|---|---|
| 0 | 8 | | 5 | |
| 0.6 | 30 | | 21 | |
| 1.0– 1.9 | 40 | | 16 | |
| 2.0– 4.9 | 22 | | 21 | |
| 5.0– 9.9 | 0 | 0 | 24 | 37 |
| 10.0–14.9 | 0 | | 7 | |
| 15.0–19.9 | 0 | | 4 | |
| 20.0–30.0 | 0 | | 2 | |
| Totals | 100 | | 100 | |

set forth in condensed form. In the dry-cleaning group, the spoilage was never greater than 5% of their eggs while in the wet-washing group, spoilage exceeded 5% in eggs from 37% of the farms. Thus, it is clear that the main contributors of infected eggs are those farms using wet-washing methods, which, for purposes of this survey, included: wiping the eggs with a damp cloth, soaking in water or water solutions, and mechanical wet-washing devices. Dry-cleaning methods included manual abrasive cleaning with sandpaper, the use of dry, abrasive powders and mechanical dry-cleaning.

The comparative results from the dry and wet-cleaning farms are further condensed in Table 4. Of the eggs produced on the 37 farms using dry-cleaning methods, 40.1% normally were cleaned, based on statements from the farmers. The range of spoilage was from 0-4.6% and the average spoilage for the 37 farms, 1.34%. In the wet-washing group (57 farms) the average number cleaned amounted to 34.8%, based on farmers' statements. The spoilage range was from 0-25.8% for individual farms and the average spoilage for all farms in the group.

**TABLE 4**

**Comparison of egg spoilage from farms using dry-cleaning with that from farms using wet-washing**

| | Dry-Cleaning | Wet-Washing |
|---|---|---|
| Number of farms | 37 | 57 |
| Number of eggs | 6,585 | 10,067 |
| Eggs cleaned | 40.1% | 34.8% |
| Range of spoilage | 0–4.6% | 0–25.8% |
| Average spoilage | 1.34% | 4.48% |

4.48%. This shows again the greater severity of infection in wet-washed eggs than in dry-cleaned eggs.

**Relation of breed to spoilage of eggs.** In analyzing the data in relation to breeds of birds, the following groupings were made: (1) Leghorns (31 farms); (2) New Hampshires (25 farms); (3) Cross-breeds (23 farms)—mainly crosses between Leghorns and New Hampshires and at least one member of the cross was from either one or the other of these two breeds; and (4) Mixed flocks (14 farms)—on which were found mixed flocks of some of the following breeds: Leghorns, New Hampshires, Barred Plymouth Rocks, Rhode Island Reds and cross-breeds. One farm having Black Australorps was omitted from this study, leaving a total of 93 farms.

Since a difference had already been observed between the wet and dry-cleaning of eggs in respect to spoilage, the spoilage data of the various breed groups was broken down into dry and wet-cleaning sub-groups for each breed. The data are set forth in Table 5. The spoilage in dry-cleaned eggs from Leghorns,

**TABLE 5**

**Relation of breed and dry and wet-cleaning to spoilage of eggs**

| Breed | Method of cleaning | Number of farms (approx. 180 eggs per farm) | Percent spoilage |
|---|---|---|---|
| Leghorns | Dry | 13 | 1.35 |
| | Wet | 18 | 5.83 |
| Hampshires | Dry | 11 | 1.29 |
| | Wet | 14 | 1.48 |
| Crosses | Dry | 10 | 1.47 |
| | Wet | 13 | 5.67 |
| Mixed | Dry | 2 | 1.10 |
| | Wet | 12 | 4.68 |

New Hampshires, cross-breeds and mixed flocks (1.3%, 1.29%, 1.47% and 1.10%, respectively) was not significantly different when analyzed statistically. On the other hand, the spoilage of wet-washed New Hampshire eggs (1.48%) was significantly less than the spoilage in wet-washed eggs of Leghorns, cross-breeds and mixed breeds (5.83%, 5.67% and 4.68%, respectively). The difference in spoilage between the wet and dry-cleaned New Hampshire eggs (1.29% and 1.48%, respectively) was not statistically significant, whereas the difference in spoilage between the dry and wet-cleaned eggs within each of the other breed groups was significant.

**Comparison of wet and dry mechanical cleaning in relation to spoilage.** Among the 94 farms investigated, 8 farms used mechanical dry-cleaning of eggs and eight mechanical wet-washing. The spoilage in eggs from these 16 farms together with the breed data is presented in Table 6. In view of the effect of breed on susceptibility of eggs to spoilage as shown in the results above (Table 5), it is fortunate that the dry-cleaning and the wet-washing groups are rather well balanced in respect to breeds. Each group contained 3 cross-breed farms and 4 Leghorn farms, the only difference being that one farm in the dry-cleaning group had a New Hampshire flock whereas the remaining farm in the wet-washing group had a mixed breed flock. Since eggs from neither the New Hampshire flock nor

**TABLE 6**

**Comparison of dry and wet mechanical cleaners from standpoint of egg spoilage**

| Dry cleaning | | | | Wet washing | | | |
|---|---|---|---|---|---|---|---|
| Farm no. | Breed | % Cleaned | % Spoilage | Farm no. | Breed | % Cleaned | % Spoilage |
| 13 | Cross | 60 | 1.1 | 5 | Cross | 20 | 6.8 |
| 26 | Cross | 10 | 2.8 | 22 | Cross | 30 | 0.0 |
| 42 | Cross | 50 | 1.1 | 56 | Leghorn | 40 | 3.9 |
| 71 | Hampshire | 10 | 0.0 | 62 | Cross | 100 | 11.8 |
| 82 | Leghorn | 100 | 0.6 | 79 | Leghorn | 100 | 17.6 |
| 86 | Leghorn | 100 | 1.1 | 87 | Leghorn | 100 | 8.5 |
| 93 | Leghorn | 100 | 1.7 | 88 | Mixed | 100 | 5.1 |
| 95 | Leghorn | 100 | 2.2 | 89 | Leghorn | 100 | 8.1 |
| Aver.: | | 66 | 1.3 | Aver.: | | 77 | 7.7 |

the mixed breed flock have spoilages distinctly removed from the average spoilage of their respective group, the inclusion of these 2 farms does not bias the data appreciably.

In the mechanical dry-cleaning group, in which 66% of the eggs are normally cleaned according to farmers' statements, the spoilage amounted to 1.3%. The average spoilage for the mechanical wet-washing group, in which 77% of the eggs are normally washed, amounted to 7.7%. This difference between the spoilage of the 2 groups was found to be statistically significant at a 2% level of probability.

**Relation of age of birds, fertility of eggs, and frequency of egg collection from the nests to spoilage of eggs.** At the time of collecting eggs from the farms, information on the age of the flocks, the fertility of the eggs and the frequency of egg collection from the nests were recorded. When the percentage spoilage of eggs from individual farms is classified on the basis of age of the flock in the manner shown in Table 7, no correlation is apparent between the age of the birds and the incidence of spoilage.

**TABLE 7**

**Relation of age of birds to egg spoilage**

| Age of birds (months) | No. of farms | Range of spoilage (percent) | Average spoilage (percent) |
|---|---|---|---|
| 6 | 5 | 0.6– 1.7 | 1.02 |
| 9 | 4 | 0 – 2.2 | 1.10 |
| 12 | 37 | 0 –25.8 | 3.14 |
| 15 | 16 | 0.6– 6.8 | 2.03 |
| 18 | 5 | 1.1–15.4 | 8.86 |
| 24 | 2 | 0 – 1.7 | 0.85 |
| 30 | 2 | 0.6– 9.0 | 4.3 |
| Mixed | 22 | 0.6–17.6 | 4.19 |

On 13 of the 94 farms, fertile or partially fertile eggs were produced and on 81 farms, non-fertile eggs. As shown in Table 8, the average spoilage for the fertile eggs was 2.79% and that for the non-fertile eggs, 3.31%. These differences in spoilage are not statistically significant.

**TABLE 8**

**Relation of fertility of eggs to spoilage**

| | No. of farms | Range of spoilage (percent) | Average spoilage (percent) |
|---|---|---|---|
| Fertile eggs | 13 | 0.6–10.0 | 2.79 |
| Non-fertile eggs | 81 | 0.0–25.8 | 3.31 |

There was considerable variation from farm to farm in the frequency with which eggs were collected from the nests. It was thought that eggs collected at closer intervals might be subject to less spoilage. Analysis of the data (Table 9) however, does not support this. On 8 farms where the eggs were collected once per day the spoilage was 2.89%; on 44 farms collecting twice per day, 4.12%; on 28 farms collecting 3 times daily, 2.29%; and on 13 farms collecting 4 or more times a day, 2.77%. These data, of course, do not exclude the possibility that eggs remaining for more prolonged periods of time in the nest, such as for 2 or 3 days, would not have been subject to an increase in spoilage.

**TABLE 9**

**Relation of frequency of egg collection from nests to spoilage of eggs**

| No. of times eggs collected daily | No. of farms | Range of spoilage (percent) | Average spoilage (percent) |
|---|---|---|---|
| 1 | 8 | 0.6– 7.3 | 2.89 |
| 2 | 44 | 0.0–25.8 | 4.12 |
| 3 | 28 | 0.0–13.3 | 2.29 |
| 4 or more | 13 | 0.6–15.4 | 2.77 |

## DISCUSSION

The lower mainland area of British Columbia produces about 80% of the eggs of the Province. Since the 94 farms included in this survey were distributed throughout the greater part of this district, it may be assumed that the results of this survey are fairly representative for eggs produced on farms in British Columbia.

This survey differs from those reported by most other investigators in that it is more extensive and the individual farms have been selected at random. Furthermore, in this study the eggs were stored at temperatures which promote the development of non-fluorescent as well as fluorescent spoilage bacteria, whereas most other investigations have been restricted to the examination for spoilage of eggs that have been held under cold storage conditions. Under cold storage conditions, as reported by Starr *et al. (10)*, development of fluorescent type spoilage organisms occurs while the growth of non-fluorescent organisms is depressed. Thus a true index of bacterial spoilage of eggs is not always obtained on examining eggs coming directly from cold storage.

The results of this study show very clearly that the eggs infected with spoilage bacteria do not come from a relatively small number of farms in an egg-producing community, but rather from a large proportion of the farms. The percentage of infected eggs from individual farms, however, varies considerably. Eggs from 6 of the 94 farms were completely free from spoilage bacteria and another 23 farms had 0.6% infected eggs. The remaining 65 farms (69%) had more than 1% of their eggs infected and must be regarded as producers of eggs of potentially unsatisfactory quality. The average spoilage for the 94 farms, 3.9%, was slightly less than the 4.9% found in the 4,821 eggs examined in a previous study *(11)*. The results obtained in the previous study, however, were biased by the selection of farms suspected of producing spoiled eggs. It must also be appreciated that in the present study heavy-dirty eggs were excluded and, although the estimated production of heavy-dirty eggs from all farms was only 6.51%, if the heavy-dirties had been included the percent spoilage would probably have been higher, as suggested by results obtained in the earlier work.

Confirming the work of Johns *(4)* and that previously done in this laboratory *(11)*, non-fluorescent types of spoilage bacteria have again been found responsible for a large segment (28.8%) of the spoiled eggs. Considering eggs from individual farms, the data show that non-fluorescent and fluorescent infecting organisms are associated in egg spoilage, and that only non-fluorescent bacteria do not prevail on some farms and only fluorescent bacteria on others.

Many investigators have shown that wet-washed eggs show a higher percentage of bacterial spoilage than dry-cleaned eggs *(2, 3, 5, 6)*. On the other hand, a number of investigators *(1, 7, 8, 9, 12)* have reported little or no harm from washing eggs. There are probably two main reasons for these inconsistencies in results. One is that in many cases inadequate numbers of eggs were included in the studies, and the second is that the eggs were either washed under carefully specified, controlled conditions or were obtained from a relatively small number of farms. The laboratory study of the effect of washing eggs on spoilage reveals little of what may happen in the actual farm practice. This work also shows the importance of including a large number of farms in this kind of study. For example, of the 6 farms out of 94 showing no infection, 3 used wet-washing methods and one of these three used a mechanical wet-washer. Although a further study of such farms might show how to use wet methods safely, the level of egg spoilage on these farms cannot be considered representative of that occurring on most farms using wet-washing techniques.

In a study made by Lorenz *et al. (6)* covering 22 farms mechanically wet-washing 100% of the eggs, the average spoilage was 7.01% compared to 7.7% found in the present study. Although the figure obtained from Lorenz's data is slightly less than that obtained in this work, the comparison can only be approximate as there is no way of compensating for the additional spoilage that may have been caused by non-fluorescent types of organisms in Lorenz's spoilage values. But the percentage spoilage of eggs due to wet-washing is of the same order in both cases.

That the spoilage of eggs from New Hampshires is statistically less than that from Leghorns and cross-breeds is very interesting and may prove to be a valuable lead in discovering means of protecting eggs against spoilage by bacteria. So far as known, there are no reports in the literature indicating that eggs from New Hampshires are more resistant to infection than eggs from other breeds. It may be that the difference is due to Leghorn eggs being more porous than those from New Hampshires. This point is under study.

The age of the birds, the fertility of the eggs or the frequency with which eggs are collected from nests appear not to have any bearing on the bacterial spoilage of eggs. However, some qualification may be necessary in connection with the frequency of egg collection. In this study, heavy-dirty eggs were excluded from the shipments. As indicated in an earlier study *(11)*, heavy-dirty eggs may carry an appreciably higher percentage of spoilage than nest-clean eggs. Also, it is common knowledge that the longer eggs remain in the nest, the greater is the opportunity for these eggs to become dirtied by faecal matter. The data of Table 9 accordingly, must be interpreted as showing that there is no significant connection between frequency of egg collection and percentage egg spoilage as long as only nest-clean eggs are considered.

A factor that might be of considerable importance in the bacterial spoilage of eggs is the storage conditions of the eggs after collection from the nest. A detailed study might be justified in order to determine the importance of this part of the operations in relation to egg spoilage, should the level of spoilage in dry-cleaned eggs not be explainable or reducible by other means.

## SUMMARY

In a study on eggs from 94 farms, less than 1% infection was found in eggs from 29 farms (38.8% of the farms) and more than 1% infection in 65 farms (69.2% of the farms). The spoilage ranged from 0-25.8% in eggs from individual farms, and the average spoilage for all farms was 3.19%.

Non-fluorescent bacteria exclusively caused spoilage of 28.8% of the rotten eggs. The incidence of fluorescent and non-fluorescent bacteria was not restricted to particular farms but was equally general for both types.

From farms using dry-cleaning methods the average rate of bacterial spoilage was 1.34% whereas from farms using wet methods it was 4.48%. The highest rate of infection from a farm using dry-cleaning methods was less than 5% whereas 37% of the farms using wet methods showed a spoilage rate above 5%.

The spoilage of wet-washed New Hampshire eggs was statistically less than that of wet-washed eggs from other breed groups, and was no higher than that for dry-cleaned New Hampshire eggs.

Eggs from eight farms using mechanical dry-cleaners had a spoilage of 1.3% and eggs from a similar number of farms using wet-washers, 7.7%.

The spoilage of eggs was not correlated with the age of the birds, the fertility of the eggs or the frequency of egg collections from the nests.

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# Bacterial Spoilage of Shell Eggs. III. Farm Practices Promoting Spoilage

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**The spoilage of unwashed, nest-clean eggs from standard litter nests or from wire, roll-away nests, is too low to be of concern in the commercial marketing of eggs. Although the use of dirty flats and trays is to be discouraged, it has been found by these studies that dirty trays do not cause a significant increase in bacterial spoilage of the eggs packed in them. Heavy soiling of eggs on the farm results in a significant increase in spoilage over that found in unwashed, nest-clean eggs, and it is sufficiently high to constitute a problem when such eggs are cleaned and brought into the commercial market. Mechanical wet-washing of eggs, even when carried out to the best of the farmers' abilities, results in sufficient bacterial spoilage of the eggs to be of grave concern in commercial operations.**

A survey of eggs from 94 farms *(6)* showed that eggs infected with spoilage organisms did not originate in a few farms in the farming community, but were encountered generally and came from most farms shipping eggs to market. The sources of infection must therefore be sought by a study of farm practices generally employed.

A preliminary study *(5)* showed that soiling of eggs increased the amount of bacterial spoilage, although the number of farms under test had been too small to give an accurate assessment of the importance of this factor. It is usually assumed that more than 99% of all eggs are clean at the time they are laid *(1, 4)*. However, for purposes of the present study, there was no accurate information to indicate whether or not clean eggs coming from nests carried appreciable infection by spoilage organisms. Another cause of infection was suggested by the use of dirty flats and trays, although, again, no substantial data were available.

A limited study on eggs from farms using mechanical wet-washing machines showed that these machines substantially increase the number of potentially spoilable eggs *(6)*. To what extent improper use of the mechanical washers had been responsible for the increase in spoilage is not known. To provide a fair test of mechanical washers, a more extensive program is necessary, which would include a study of the quality of the eggs when washed by machines operated according to manufacturers' instructions, particularly in respect to sanitation and wash-water temperatures. The unsatisfactory performance of mechanical wet-washers may be due in a large part to a failure to operate the machines properly.

In addition to a study on farms using litter-nests, a study was also included of farms using wire, roll-away nests. Information was collected on the percentage of heavy-dirty eggs normally found on farms using both types of nests and an attempt was made to determine the efficacy of roll-away nests in relation to freedom from bacterial infection and subsequent spoilage.

## METHODS

During December, 1953, and the first half of January, 1954, eggs were collected from 27 farms in the Fraser Valley of British Columbia. From each of 15 farms which used mechanical wet-washers were obtained 15 dozen eggs in each of the 5 following groups: (1) unwashed, nest-clean eggs packed in clean trays; (2) unwashed, nest-clean eggs packed in dirty trays; (3) unwashed, heavily-soiled eggs; (4) eggs washed by machine operated by farmer in usual manner; and (5) eggs washed by machine by the farmer after thorough cleaning of the machine and using water at a temperature of 130-135° F. at the surface of the egg. From each of the 12 remaining farms, which employed wire, roll-away nests, 15 dozen eggs were obtained.

Heavily-soiled eggs were classified as those having a dirty area on the shell equivalent to that of a thumb nail. The farms were provided with previously standardized, armoured thermometers by which the farmer was able to adjust and regulate the temperature of the water used in washing. The farmer was given instructions on cleaning the washing machine and directions as to the use of the thermometer. There was no interference by technical people during these operations by the farmer, as it was desired that performance be representative of actual farm practice.

Eggs from the farms were packed in individual cartons containing 15 dozen eggs and these were delivered to the laboratory within 24 hours and were then stored in a thermostatically controlled room at 60° F. (15° C.) for a period of 6 to 7 weeks. At the end of this time all eggs were individually broken into open Petri plates and examined under a black-light candling lamp (Vogelite, Model 301A) for indications of rot. Rotten eggs from each group were classified under black-light as "fluorescent" or "non-fluorescent."

Mechanical washing of eggs on farms was done either with a "rubber-roller" type or "brush" type machine. The former turns the eggs end-over-end until clean, at which time they are manually removed. The eggs are wetted by individual streams of water drawn from a tank immediately beneath the eggs and to

which the water returns after leaving the eggs. The water in the tank may be heated and maintained at a constant temperature thermostatically. Cleaned eggs are dried in a stream of warm air.

The brush type of machine is equipped with a horizontal metal conveyor which carries eggs past a revolving bristle brush and then returns the eggs over a current of warm air. Water is drawn from a reservoir and distributed along the length of the revolving brush which is fixed in the horizontal plane. The water may be heated in the reservoir, and is only used once, then drained away.

## EXPERIMENTAL

**Examination of eggs.** In planning the study on eggs from farms using mechanical wet-washers and farms using wire, roll-away nests, all known farms in the Fraser Valley area using such equipment were contacted. Mechanical wet-washers were being used on 23 farms and wire, roll-away nests on 13. When the egg collections were made some of the mechanical washers were no longer operating, and some farmers refused to supply mechanically washed eggs, so that the total number of farms in this group was reduced to 15. All 13 farms using wire, roll-away nests submitted eggs for this study, but as the eggs from one of these farms had been washed, the number of such farms included in this study was 12.

From 27 farms were obtained 15,201 eggs, from which 61 cracks were discarded, leaving 15,140 eggs for study. At the time of examination, about 7 weeks after laying, the non-fluorescent rots accounted for 50 out of a total of 478 rots, or 10.5%. The cause of spoilage of most of the remaining 428 eggs (89.5%) was probably a combination of fluorescent and non-fluorescent bacteria.

**Spoilage in nest-clean eggs and heavy-dirty eggs from litter nests.** A description of the litter-nest farms and the spoilage of nest-clean and heavy-dirty eggs from these farms is shown in Table 1. Nine of the farms had Leghorn, four had mixed flocks, and two had cross-breeds. Excepting for one farm (No. 8) which had 2-3 year-old Leghorns, all birds were young layers. Nesting material was either straw or shavings and straw; shavings or peat were used for floor litter. Sanitation ranged from *bad* to *excellent* and did not seem to bear any relation to the incidence of spoilage in either the nest-clean eggs or in the heavy-dirty eggs. The spoilage for the heavy-dirty eggs averaged 2.37% for all farms, and was statistically greater than the 0.42% spoilage for the nest-clean eggs. Farm No. 9 whose eggs, both nest-clean and heavy-dirty, showed much greater spoilage than average was the only farm with a history of leucosis in the flock.

The average production of heavy-dirty eggs from this group of farms was 7.9%. Since 76% of the eggs were normally washed before going to market, according to farmers' statements, there was good evidence that the percentage of light-dirty eggs was high.

**Spoilage of eggs packed in dirty trays.** The effect of dirty trays as a possible contributor to bacterial infection of eggs was determined by packing nest-clean eggs in dirty trays, and comparing the subsequent spoilage of these eggs with that of nest-clean eggs packed in clean flats and trays. The eggs were retained in the flats and trays for the full 7 weeks' storage period at 60° F. (15° C.) and then the eggs broken open individually and examined for spoilage. The data represented in Table 2 show the spoilage of eggs packed in dirty flats and trays was 1.6% compared with 0.42% for the nest-clean eggs from the same farms packed in clean flats and trays. Since the difference between 1.60% and 0.42% was not statistically significant at the 5% probability level, dirty trays could not be considered an important cause of bacterial infection of the eggs in this particular study. However, the dirtiness of trays is a matter of degree and if the trays are sufficiently dirty they may contribute to an increase in egg spoilage as suggested by the eggs from farms No. 9, 12, 17 and 24.

TABLE 2

**Comparison of spoilage in nest-clean eggs packed in clean flats and trays and in dirty flats and trays**

| Farm No. | Clean flats and trays | | Dirty flats and trays | |
|---|---|---|---|---|
| | No. eggs | % spoilage | No. eggs | % spoilage |
| 2 | 178 | 0.0 | 180 | 0.0 |
| 3 | 180 | 0.6 | 173 | 0.6 |
| 4 | 180 | 0.0 | 180 | 0.6 |
| 5 | 180 | 0.6 | 180 | 1.8 |
| 6 | 180 | 0.0 | 180 | 0.0 |
| 7 | 180 | 0.0 | 180 | 0.0 |
| 8 | 180 | 0.0 | 180 | 0.0 |
| 9 | 180 | 2.5 | 177 | 4.0 |
| 12 | 180 | 0.0 | 179 | 7.2 |
| 17 | 180 | 0.6 | 180 | 3.3 |
| 24 | 180 | 0.6 | 180 | 5.0 |
| 30 | 179 | 0.6 | 180 | 0.0 |
| 34 | 180 | 0.0 | 180 | 0.0 |
| 35 | 180 | 0.6 | 180 | 0.0 |
| 36 | 180 | 0.6 | ..... | ..... |
| Average | | 0.42 | | 1.60 |

**Spoilage in mechanically washed eggs.** Descriptions of the mechanical wet-washing methods used on the 15 farms and the spoilage in the eggs from these farms are shown in Table 3. The number of washed eggs from individual farms ranged from 15 to 100%, was 100% on most farms, and averaged 76% for all farms. The percentage spoilage in mechanically washed eggs from all farms, when no special instructions were given to the farmers, was 7.44%. After the first collection of washed eggs was made, a second set was collected from each farm. These were to have been washed after a thorough cleaning of the washing machine

TABLE 1

**Description of litter-nest farms and spoilage of unwashed nest-clean and heavy-dirty eggs**

| Farm No. | Breed | Age | % Heavy-dirty | Nest | Litter | Sanitation | Disease history | % Spoilage | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Nest-clean | Heavy-dirty |
| 2 | Mixed | pullets | 1 | shavings | shavings | fair | none | 0.0 | 1.7 |
| 3 | Leghorn | pullets | 2 | straw | sawdust, straw | fair | none | 0.6 | 1.2 |
| 4 | Leghorn | pullets | 3 | shavings | sawdust, 8" | fair | none | 0.0 | 0.6 |
| 5 | Leghorn | pullets | 3 | shavings | peat | excellent | none | 0.6 | 1.8 |
| 6 | Leghorn | pullets | 1 | shavings | sawdust, 8" | fair | Coccidiosis, worms | 0.0 | 1.8 |
| 7 | Leghorn | pullets | 1 | shavings | sawdust, 8" | fair | none | 0.0 | 0.0 |
| 8 | Leghorn | 2-3 yrs. | 2 | straw | straw, peat, lime, 8" | fair | none | 0.0 | 3.4 |
| 9 | Mixed | pullets | 4 | shavings | sawdust | ..... | Leucosis | 2.5 | 11.0 |
| 12 | Mixed | 10 mo. | 5 | shavings | peat, shavings | good | none | 0.0 | 0.6 |
| 17 | Cross | 10 mo. | 20 | straw | straw | good | Newcastle | 0.6 | 0.6 |
| 24 | Leghorn | pullets | 5 | shavings | shavings, 6" | good | none | 0.6 | 5.6 |
| 30 | Cross | 14 mo. | 10 | shavings | peat, shavings, 3" | good | none | 0.6 | 1.1 |
| 34 | Leghorn | 6-12 mo. | 0.5 | straw, shavings | ..... | good | none | 0.0 | 3.0 |
| 35 | Leghorn | 11 mo. | 60 | straw | shavings | bad | none | 0.6 | 1.1 |
| 36 | Mixed | pullets | 2 | shavings | sawdust, 8" | fair | none | 0.6 | ..... |
| Averages | | | 7.9 | | | | | 0.42 | 2.37 |

**TABLE 3**

**Description of mechanical wet-washing methods on farms and spoilage of washed eggs**

W-I indicates spoilage of eggs washed in usual manner.
W-II indicates spoilage of eggs washed on cleaned machine using water at 130-135° F. at egg surface.

| Farm No. | Percent cleaned | Machine [1] | Water temp. deg. F. | Detergent | Cleaning of machine | Cleaning agent | % Spoilage | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | W-I | W-II |
| 2 | | B | 160 | | 3 × week | Roccal | 1.1 | 0.0 |
| 3 | | B | hot | | daily? | Diversol | 5.1 | 3.3 |
| 4 | 100 | B | warm | | daily? | ..... | 1.7 | 0.0 |
| 5 | 100 | A | ..... | Kleenade | bi-monthly | Izal | 4.5 | 5.0 |
| 6 | 100 | A | 130 | none | daily | none | 0.0 | 0.0 |
| 7 | 100 | A | warm | none | daily? | bleach | 0.0 | 0.0 |
| 8 | 100 | A | 110 | none | daily | | 7.8 | 3.9 |
| 9 | 100 | A | warm | none | daily | none | 18.1 | 22.6 |
| 12 | 25 | B | 100 | none | daily | soap | 5.6 | 3.3 |
| 17 | 15 | B | 100 | none | bi-weekly | none | 13.4 | 11.7 |
| 24 | 25 | A | 135 | | daily | Izal | 19.8 | 15.6 |
| 30 | 100 | B | ..... | none | daily | none | 2.3 | 0.6 |
| 34 | 100 | A | 120 | none | daily | none | 0.0 | 0.6 |
| 35 | 75 | B | 130 | Breeze | bi-weekly | Breeze | 16.1 | 15.5 |
| 36 | 50 | A | 105 | K.D.C. | daily | K.D.C. | 16.5 | 8.9 |
| Averages | 76 | | | | | | 7.44 | 6.06 |

[1] A—Rubber-roller type. B—Brush type.

**TABLE 4**

**Spoilage of unwashed, nest-clean eggs from wire, roll-away nest farms**

| Farm No. | Breed | Age | % cleaned | % heavy-dirty | Litter | Sanitation | Disease history | % spoilage |
|---|---|---|---|---|---|---|---|---|
| 1 | Leghorn | 9 mo. | 15 | 1 | ..... | good | none | 0.0 |
| 15 | Cross | 11 mo. | 0 | .. | ..... | very good | none | 0.0 |
| 16 | Leghorn | 11 mo. | 10 | 3 | peat-moss | good | Coccidiosis | 0.6 |
| 18 | Hampshire | 9 mo. | 10 | 3 | sawdust 6" | good | Newcastle | 1.1 |
| 19 | Cross | 10 mo. | 10 | 1 | wire | ..... | Newcastle | 0.0 |
| 20 | Cross | 6 mo. | 5 | 0.5 | wire | ..... | Newcastle | 0.6 |
| 21 | Cross | 10 mo. | 5 | 1 | wire | ..... | none | 0.0 |
| 31 | Cross | 8 mo. | 0 | 0 | ..... | good | none | 0.0 |
| 32 | Hampshire | 7 mo. | 2 | 0 | ..... | good | none | 3.9 |
| 33 | Cross | pullet | 2 | 2 | cages | excellent | Newcastle | 0.0 |
| 37 | Hampshire | 7-10 mo. | 15 | 1 | ..... | good | Newcastle, Leucosis | 1.7 |
| 38 | Leghorn | 10 mo. | 1 | 0.5 | ..... | good | Leucosis, Newcastle | 0.6 |
| Averages | | | 6.7 | 1.1 | | | | 0.69 |

and using water at 130-135° F. at the point where the water came in contact with the egg surface. The percentage spoilage in the eggs washed under these conditions from all farms was 6.06%. This was not significantly different at the 5% probability level from the 7.44% spoilage obtained in the first set of eggs.

Of the two makes of washing machines employed, referred to in the Table as "A" and "B," neither could be considered satisfactory from the standpoint of preventing spoilage of eggs during washing. Three farms used detergents in washing eggs, and the normal spoilage of eggs from these farms was 4.5, 16.1 and 16.5%, indicating that the detergents did not reduce spoilage.

**Spoilage in eggs from roll-away nests.** A description of the 12 farms with wire, roll-away nests and the spoilage of the eggs from these farms is shown in Table 4. Three of the farms had Leghorns, six had cross-breeds, and three farms had New Hampshires. The birds of all flocks were under one year old. The sanitation of these operations was either *good* or *excellent* and was generally superior to that of the litter-nest farms. The average spoilage of eggs from all 15 farms was 0.69%, and was statistically no different from that (0.42%) for the nest-clean eggs from the litter-nest farms. Excepting farm No. 32, which had a spoilage of 3.9%, spoilage of eggs at all farms was very low. From the data submitted there is no evident reason why the spoilage of eggs on farm No. 32 should have been so high.

It is interesting to note the low percentage of eggs normally cleaned (6.7%) and the low percentage of heavy-dirty eggs which occurred on these farms (1.2%, compared to 6.6% for litter-nest farms).

## DISCUSSION

In Table 5 is given the number of eggs in each group tested, the range of spoilage for the group, and also the average percent spoilage. It must be realized that, with the exception of the eggs from wire, roll-away nests, the various groups of eggs were obtained from the same farms. Each group contained over 2,000 eggs and the data were examined statistically for differences between groups.

**TABLE 5**

**Range and percent spoilage of eggs in different groups**

| Group | Treatment | No. farms [1] | No. eggs | Range of spoilage, % | Spoilage [2] % |
|---|---|---|---|---|---|
| A | Nest-clean | 15 | 2700 | 0.0– 2.5 | 0.42 |
| B | Dirty trays | 14 | 2520 | 0.0– 7.2 | 1.60 |
| C | Heavy-dirties | 14 | 2360 | 0.0–11.0 | 2.37 |
| D | Washed I | 15 | 2700 | 0.0–19.8 | 7.44 |
| E | Washed II | 15 | 2700 | 0.0–22.6 | 6.06 |
| F | Roll-away nests | 12 | 2160 | 0.0– 3.9 | 0.69 |

[1] Eggs of all groups, except those from roll-away nests, collected from same farms.

[2] Values for A, B and F not signicantly different at 5% level.
Values for D and E not significantly different at 5% level.
Values for A and C significantly different at 1% level.
Values for A, B and F all significantly different from D and E at 5% level.

Unwashed, nest-clean eggs did not show significant differences in spoilage whether packed in clean or dirty trays. Nor was the spoilage in eggs from wire, roll-away nests significantly different from that of unwashed nest-clean eggs from litter-nests. The spoilage

in heavy-dirty eggs was significantly higher than that of unwashed nest-clean eggs from the same farm.

The spoilage in eggs washed by machine in the normal manner ranged from zero on 3 farms to as high as 19.8%, and the average spoilage, 7.44%, was significantly higher than the spoilage of nest-clean eggs from litter-nests or from wire, roll-away nests. When mechanical wet-washers were operated with more care, the spoilage of eggs from the different farms ranged from zero for 4 farms, to 22%, and averaged 6.06%. This was not significantly different from the level of spoilage of eggs mechanically washed in the customary manner.

In these experiments the spoilage of unwashed nest-clean eggs is less than 1% when the eggs are stored at 60° F. for 6 weeks. As eggs are stored at a much lower temperature in practice, these eggs could be considered almost commercially free of spoilage. Since these eggs had been produced on farms that had been selected without bias as to sanitation and efficient farm practices, the results are representative of what happens under practical conditions. The present study has shown that heavy soiling of eggs is responsible for a significant increase in the amount of spoilage of eggs by bacteria. These results are in agreement with studies undertaken in Missouri *(2)*, Ohio *(8)*, and by the U. S. Department of Agriculture *(3)* and point to the importance of avoiding the production of heavy-dirty eggs to the limit of practical feasibility.

In the recent survey on mechanically washed eggs from 15 farms (2,700 eggs), a spoilage of 7.44% was found. This agrees closely with an average spoilage of 7.7% in eggs from 8 farms (1,400 eggs) in an earlier investigation *(6)*. These results, taken together, indicate that washing machines, at least of the types used in the area under study, are definite promoters of bacterial spoilage of eggs and their use should be avoided.

Although the spoilage of nest-clean eggs from wire, roll-away nests appeared to be slightly higher than that of nest-clean eggs from litter-nests (0.6% compared with 0.42%, respectively), the difference was not statistically significant. In addition to providing a low spoilage among the nest-clean eggs, wire, roll-away nests have the additional advantage, according to records obtained in these studies, of providing a relatively low production of heavy-dirty eggs. In the 12 farms using wire, roll-away nests, the production of heavy-dirty eggs amounted to 1.1% of the total production, compared to 7.9% from the 15 farms using litter-nests. In addition, the total number cleaned on the former farms amounted to only 6.7% of the eggs, whereas previous studies of litter-nest farms have shown that the average number of eggs cleaned on 37 dry-cleaning farms was 40.1%, and that on 57 farms using wet-cleaning methods, 34.8%. From the standpoint of reducing both the amount of bacterial spoilage of eggs and the amount of labor and time expended by the farmer in cleaning eggs, an improved type of nest, possibly based on the wire, roll-away principle, would justify further investigation. Studies are currently being made along this line.


## SUMMARY

The spoilage of unwashed, nest-clean eggs from 15 farms averaged 0.42% and ranged between 0.0 and 2.5%.

The spoilage of unwashed eggs from roll-away nests from 12 farms averaged 0.69%, and ranged between 0.0 and 3.9%.

The spoilage of unwashed, nest-clean eggs from 14 farms when packed in dirty flats and trays, averaged 1.60% with a range of 0.0 to 7.2%. The differences in spoilage between unwashed, nest-clean eggs from litter-nests, clean eggs from roll-away nests and nest-clean eggs packed in dirty flats and trays were not significant at the 5% level.

The spoilage of soiled eggs from 14 farms averaged 2.37%, and ranged between 0.0 and 11.0%. The spoilage of these eggs was significantly higher than that of unwashed, nest-clean eggs from litter-nests and from roll-away nests.

Mechanically washed eggs from 15 farms showed an average spoilage of 7.44% with a range of 0.0 to 19.8%.

The spoilage in mechanically washed eggs from the same 15 farms, after clean-up of the washing machines and using water at 130-135° F. at the shell surface, averaged 6.06%, and ranged between 0.0 and 22.6%. Special precautions in the use of washing machines did not significantly reduce the spoilage in the eggs washed by the machines.



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# Evaluation of Thresholds and Minimum Difference Concentrations for Various Constituents of Wines. II. Sweetness: The Effect of Ethyl Alcohol, Organic Acids and Tannin

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(Manuscript received August 12, 1954)

**In an investigation of sweetness and differences of sweetness of aqueous solutions of sugars it was shown that ethyl alcohol has a marked effect upon the sugar threshold and upon minimum detectable concentration differences. It is indicated that alcohol enhances the sweetness of a sucrose solution. Tannin was shown to increase the detectable differences necessary for perception.**

The sensations of sweetness and differences in sweetness of aqueous solutions of sugars have been investigated *(2, 3)*. The effect of various pure substances on the minimum detectable differences in sweetness has not been well established. Since a number of substances other than sugar naturally occur in grape wine, it was essential that this effect on the sensation of sweetness be determined.

The triangular test technique *(4)* was employed in making the determinations. A panel of 12-16 persons was used, tasting daily. The methodology described by Berg *et al. (1)* was used for the establishment of thresholds and minimum detectable concentration differences.

Natural wines may contain as much as 14 g. per 100 ml. reducing sugar, consisting almost entirely of dextrose and levulose. These grape sugars are present in the unfermented juice in approximately equal amounts; however, the proportions in wine vary according to the degree of fermentation.

The principal non-volatile organic acids in wine are lactic, malic, succinic, tartaric and potassium acid tartrate. The approximate ranges in concentration, in g. per 100 ml., are from 0.046-0.338 for lactic acid, 0.109-0.280 for malic, 0.15-0.49 for tartaric, 0.05-0.20 for succinic and 0.10-0.50 for potassium acid tartrate. Other acids are present but in much smaller amounts.

The ethyl alcohol content in table wine is generally 10-14% by volume by natural fermentation, and may be as high as 21% in fortified wine, where brandy is added to prevent fermentation of some of the grape sugars.

Tannin is derived from the skins, stems and seeds of grapes, and is present in wine to the extent of 0.02-0.30 g. per 100 ml.

## EXPERIMENTAL

The combinations of the pure substances used in these experiments were taken in an arbitrary range; first, to conform to the composition in average wines, and second, to maintain a pH range for the acidic solutions comparable to that found in wines. All the acids used were of C. P. grade. The ethyl alcohol used was a triple-distilled neutral grape spirit of 95.5% alcohol by volume, and the tannin was an Australian grape seed tannin. The water used was distilled from a Barnstead still, and its pH range was 5.8-6.0.

The following solutions were used for testing sugar thresholds and minimum detectable concentration differences:

No. 1. *Water control.*

No. 2. *Water-acid,* pH 3.40.
Lactic acid, 0.06 g./100 ml.
Succinic acid, 0.06 g./100 ml.
Malic acid, 0.06 g./100 ml.
Pot. acid tartrate, 0.30 g./100 ml.
Total acidity as tartaric, 0.30 g./100 ml.

No. 3. *Water-acid,* pH 3.00.
Lactic acid, 0.15 g./100 ml.
Succinic acid, 0.12 g./100 ml.
Malic acid, 0.20 g./100 ml.
Tartaric acid, 0.05 g./100 ml.
Pot. acid tartrate, 0.30 g./100 ml.
Total acidity as tartaric, 0.60 g./100 ml.

No. 4. *Water-alcohol,* pH 5.90.
Ethyl alcohol, 10% by volume.

No. 5. *Water-alcohol,* pH 5.90.
Ethyl alcohol, 20% by volume.

No. 6. *Water-acid-alcohol,* pH 3.45.
Same as No. 2, in 10% alcohol solution.

No. 7. *Water-acid-alcohol,* pH 3.10.
Same as No. 3, in 10% alcohol solution.

No. 8. *Water-acid,* pH 2.55.
Malic acid 0.30 g./100 ml.

No. 9. *Water-acid-alcohol,* pH 3.55.
Same as No. 2, in 20% alcohol solution.

No. 10. *Water-acid-alcohol,* pH 3.15.
Same as No. 3, in 20% alcohol solution.

No. 11. *Water-tannin.*
Grape seed tannin 0.10 g./100 ml.

No. 12. *Water-acid-alcohol-tannin.*
Same as No. 2, with 0.10 g./100 ml. tannin added, in 10% alcohol solution.

The sugar levels were tested at the 0, 1, 5, 10 g./100 ml. concentrations generally, although in some cases a 15 g./100 ml. concentration was used.

Sucrose was used in the sweetness determinations rather than a mixture of dextrose and levulose for two reasons: first the variable purity of the levulose available, and second, the prohibitive cost of levulose in purity grade. It was found that the minimum detectable concentration differences for sucrose, at any concentration level tested, were the same as the differences for a mixture of dextrose and levulose. As an example, Table 1 shows the comparable results between sucrose and a mixture containing 50% dextrose and 50% levulose in aqueous solutions.

**TABLE 1**
**Comparison of threshold values of levulose-dextrose mixture and sucrose**

| | Total sugar concentration level g./100 ml. | | | |
|---|---|---|---|---|
| | 0 | 1 | 5 | 10 |
| Sugars | Minimum detectable conc. diff. | | | |
| Sucrose | 0.3 | 0.4 | 0.5 | 0.6 |
| 50% Dextrose-50% Levulose | 0.3 | 0.4 | 0.5 | 0.6 |

## RESULTS AND DISCUSSION

The effect of pH on the minimum detectable concentration differences was studied. No effect was noted between solution No. 8, at pH 2.55, solution No. 3, at pH 3.0, and solution No. 2, at pH 3.4, for all the levels of sugar tested. Table 2 gives the results of these determinations.

**TABLE 2**
**Effect of pH on detectable sugar differences**

| Sucrose level g./100 ml. | Minimum detectable increment in concentration g./100 ml. sucrose: Solution No. 8 pH 2.55 | Solution No. 3 pH 3.00 | Solution No. 2 pH 3.40 |
|---|---|---|---|
| 0 | 0.6 | 0.6 | 0.6 |
| 1 | — | 0.5 | 0.5 |
| 5 | 0.5 | 0.6 | 0.6 |
| 10 | 0.9 | 0.9 | 1.0 |

The effect of acids and alcohol on threshold and minimum detectable differences was very pronounced. Table 3 tabulates the results using solutions of varying acid and alcohol contents. Table 4, an analysis of variance on the results from Table 3, reveals that the single effect of sugar concentration on the minimum detectable differences is very highly significant, a result to be expected from Weber's law.

**TABLE 4**
**Analysis of variance for data from Table 3. Effect of sucrose, acid and alcohol on the minimum detectable conctnartion diff.**

| | Sum squares | Degrees freedom | Mean square | F |
|---|---|---|---|---|
| Single effects | | | | |
| Sucrose | 6.14750 | 3 | 2.04917 | 119.97*** |
| Acid | 0.23389 | 2 | 0.11694 | 6.85** |
| Alcohol | 3.45389 | 2 | 1.72694 | 101.11*** |
| Interactions | | | | |
| Sucrose × acid | 0.07500 | 6 | 0.01250 | — |
| Sucrose × alcohol | 2.05500 | 6 | 0.34250 | 20.05*** |
| Acid × alcohol | 0.13278 | 4 | 0.03319 | — |
| Sucrose × acid × alc. | 0.20500 | 12 | 0.01708 | — |
| Total | 12.30306 | 35 | | |

** Highly significant.
*** Very highly significant.

The single effect of acids is significant, but the absence of an interaction between sugar and acid denotes that the acid concentration does not affect the increment at the different sugar levels. A comparison of the effects of solutions No. 2 and No. 3 suggests that the acids tend to raise the zero threshold (the threshold at zero sugar level) as compared to sugar in aqueous solution, and that this difference carries itself through all of the sugar concentration levels.

The single effect of alcohol concentration on the minimum detectable increment in sugar concentration is very highly significant, and establishes the fact that the increment varies with change in alcohol concentration. The presence of the interaction between sugar and alcohol is highly significant, and denotes that the increment increases with increasing sugar concentration, in an alcohol solution, over and above the effect in aqueous sugar solutions. The only reasonable conclusion is that the alcohol enhances the sweetness of a sugar solution. The data of Table 5 bear out the above premise. Aqueous solutions containing 10 g./100 ml. sucrose were compared with sugar solutions containing alcohol, acid or both. The panel was asked the question, "which tastes sweeter?", in triangular comparisons. The solution judged equally sweet as 10 g./100 ml. aqueous sucrose was determined when the panel gave an equal number of decisions for each solution on the question asked. A solution containing 8 g./100 ml. sucrose in 10% alcohol was judged as sweet as an aqueous solution containing 10 g./100 ml. sucrose. Similarly, a 20% alcohol aqueous solution containing 7 g./100 ml. sucrose was deemed as sweet as 10 g./100 ml. sucrose in aqueous solution. It is interesting to note that acids have a tendency to depress sweetness.

**TABLE 5**
**Solutions of equal sweetness**

| Solution | Sucrose concentration |
|---|---|
| Aqueous | 10 g./100 ml. |
| 10% alcohol by vol. aqueous | 8 g./100 ml. |
| 20% alcohol by vol. aqueous | 7 g./100 ml. |
| 0.30 g./100 ml. acid aqueous | 16 g./100 ml. |
| 0.60 g./100 ml. acid aqueous | 17 g./100 ml. |
| 10% alcohol, 0.30 g./100 ml. acid | 12 g./100 ml. |

Due to the astringency of tannin, only a few tests were conducted for its effect upon sugar thresholds and detectable differences. However, it was found that the primary effect of tannin was to increase these values significantly over those obtained for sucrose in pure aqueous solutions. The panel could detect the differences between the following aqueous solutions, (in g./100 ml. sucrose), containing 0.10% Australian grape seed tannin: 0 and 0.8; 1.0 and 1.8; 5.0 and 5.8; and 10.0 and 11.5.

The results for the minimum detectable concentration differences indicated that a straight line relationship existed between the minimum higher detectable concentration, $C_i$, and the concentration being tested, $C_o$, for all the levels of sucrose used. In other words,

$$C_i = KC_o + A \qquad (1)$$

where K is a constant and A is the zero threshold (the threshold at $C_o = O$).

Figure 1 shows this condition of linearity to be essentially true. Also, the differences in slopes among the lines reflect the effects of the presence of alcohol and acid.

Table 6 gives the values for the slope K, calculated from equation 1, for a number of the solutions tested. The lines were

**TABLE 6**
**Values for K for various solutions, given by the equation $C_i = KC_o + A$**

| Solution No. | K |
|---|---|
| 1 | 1.036 |
| 2 | 1.057 |
| 3 | 1.034 |
| 4 | 1.150 |
| 5 | 1.182 |
| 6 | 1.063 |
| 7 | 1.095 |
| 8 | 1.028 |
| 9 | 1.180 |

**TABLE 3**
**The effect of aqueous acid and alcohol solutions on minimum detectable concentration differences for sucrose**

| Sucrose level g./100 ml. | Solution [1]: No. 1 | No. 4 | No. 5 | No. 2 | No. 6 | No. 9 | No. 3 | No. 7 | No. 10 |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 0.3 | 0.4 | 0.5 | 0.6 | 0.8 | 0.8 | 0.6 | 0.7 | 0.8 |
| 1 | 0.4 | 0.6 | 0.7 | 0.5 | 0.7 | 0.9 | 0.5 | 0.7 | 0.9 |
| 5 | 0.5 | 1.0 | 1.0 | 0.6 | 0.8 | 1.5 | 0.6 | 1.0 | 1.5 |
| 10 | 0.6 | 1.8 | 2.4 | 1.0 | 1.4 | 2.6 | 0.9 | 1.5 | 2.6 |
| 15 | 0.9 | 2.7 | — | 1.4 | — | — | — | — | — |

[1] Solutions are numbered as in the text; differences in concentration are in g./100 ml.

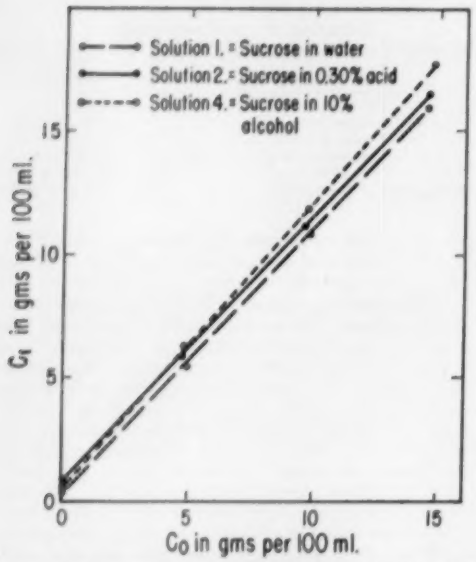
Solution 1. = Sucrose in water
Solution 2. = Sucrose in 0.30% acid
Solution 4. = Sucrose in 10% alcohol
$C_t$ in gms per 100 ml.
$C_0$ in gms per 100 ml.
0
5
10
15

**Figure 1. The effect of various substances on the minimum detectable concentration differences in sucrose.**

tested for linearity by statistical analysis, and departures from linearity were found to be insignificant in all cases.

The effect of alcohol on the slope is marked, while the effect of acid appears to be essentially an elevation of the zero threshold. It may be that the value for A depends mainly upon individual panel acuities, while K may be free from panel characteristics, depending only upon the composition of the particular solution being tested. No experimental work was conducted in this direction. However, the work of Dahlberg and Penzcek *(3)* gives the following results for sucrose in aqueous solution, in percent by weight, for an experienced panel, each pair of solutions being barely differentiated from one another: 2.07 and 2.0; 10.25 and 10.0; 20.5 and 20.0; 31.0 and 30.0; 41.5 and 40.0; 52.0 and 50.0. A calculation of the best straight line gives a slope of the line, K, equal to 1.039. From Table 6, the slope for solution No. 1 gives K = 1.036. The comparison of the two above independent results strongly suggests that K is independent of the tasters.

If equation 1 is rearranged to the form,

$$\frac{C_t - C_o - A}{C_o} = K\text{-}1 \qquad (2)$$

and $C_t - C_o$, the minimum detectable concentration difference, is designated $\Delta C$, K-1 is designated k, then

$$\frac{\Delta C\text{-}A}{C_o} = k \qquad (3)$$

One statement of Weber's law is that to produce a barely detectable difference in sensation resulting from a given stimulus a definite fraction of the stimulus must be added to it, so that

$$\frac{\Delta C}{C} = \text{a constant} \qquad (4)$$

A comparison of equations 3 and 4 gives the appearance that Weber's law may be a special case of equation 3, occurring when A = O. This would account for the fact that Weber's law fails at low concentrations and applies mainly for moderate concentrations of sucrose, since the value for A contributes a large proportion to the ratio in 3 at low concentrations, and has a decreasing effect on the ratio as $C_o$ increases.

## SUMMARY

A determination of thresholds and minimum detectable differences for sucrose at 0, 1, 5, 10, and 15 g. per 100 ml. concentration levels was made using aqueous, ethyl alcohol-water, acid-water and alcohol-acid-water solutions. The effect of tannin was also determined.

No effect was noted due to pH for pH values from 2.55 to 3.40. The primary effect of acids appears to be an increase in the value for the zero threshold.

Ethyl alcohol has a marked effect upon the sugar threshold and minimum detectable concentration differences. It is suggested that alcohol enhances the sweetness of a sucrose solution.

Tannin increased the detectable differences necessary for perception.

A plot of the results reveals a significant linear relationship between the minimum detectable concentration differences and the concentration of sucrose being tested. Weber's law may be a special case of this linear relation.

### Acknowledgment

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# Refrigeration of Tuna and Sardines by Sodium Chloride Brines[a]

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**The refrigeration of tuna and sardines by sodium chloride brines has been studied. The factors investigated were spoilage prevention, salt penetration and protein denaturation. The data for tuna were incorporated in the design of the refrigeration system installed on board the first tuna clipper using brine refrigeration. A series of recommendations of a practical nature have been suggested for the brine chilling and freezing of tuna, sardines, mackerel and herring on board fishing boats as well as in canneries.**

Preserving fish and other foods by cold can be regarded as an ancient art. It has been practiced from the earliest times, particularly in Northern climates. During the latter part of the 19th century, when mechanical refrigeration became available, cold began to be used rather extensively for the preservation of fish and other perishable foods. Although refrigeration offers the only means of preserving fish in essentially its original condition over extended periods and during long distance transportation, frozen fish were long regarded with suspicion and the rather widespread use of frozen fish products is of relatively recent date. Most of the refrigeration of fish was applied to such species as herring, the flat fishes, cod, haddock and salmon. Even for these fish the refrigerant has been, and still largely is, ice. The application of mechanical refrigeration on shipboard has been very restricted; primarily coils have been installed to minimize the loss of ice and only secondarily to obtain some additional cooling effect.

Work was initiated in this laboratory in July 1937 on the best means to preserve tuna on board the fishing vessels. The immediate incentive was the large losses of raw and precooked tuna experienced by the fishing fleet. With the increased demand for tuna the fishing boats began to make longer cruises, up to 10,000 miles from home port, to newer fishing grounds, which lengthened the storage period for the fish to three months or more. The high water and fish temperatures encountered, ranging up to 85° F. or higher, the inadequate refrigeration, mainly ice, and the long storage periods in the holds—all combined to produce a situation where entire loads were often rejected on account of decomposition. Monetary losses of millions of dollars resulted. The problem then resolved itself into two separate phases, namely the prevention of spoilage on the tuna vessels and the development of an accurate and reliable means of evaluating spoilage in the fish during all the operating stages. The results of the second phase of the study have already been presented in previous reports *(5, 8)*, in which the Volatile Reducing Substances (V.R.S.) method has been described and compared with other procedures. A preliminary report of some aspects of the first phase of the study, the preservation of the tuna, has also been reported *(7)*. An outline of the work by the U. S. Fish and Wildlife Service on the freezing of fish at sea has recently appeared *(2, 6, 10)*. The early history of fish refrigeration has been reviewed by Taylor *(15)*.

During World War II work was undertaken on the temporary preservation of sardines and mackerel in the canneries. Temporary preservation would enable a regular working day to be set up, an inducement for the recruitment of cannery labor. Studies were conducted on the rates of chilling of these fish and their storage capabilities at various temperatures above 32° F. The results of these studies are given below.

Among the factors involved in the refrigeration and storage of fish which are discussed in this report are the cooling and freezing rates of fish at various temperatures and their relation to spoilage, salt penetration, and the development of deleterious changes in the composition of the fish other than those resulting from spoilage. The data obtained represent the joint efforts of a group of individuals who were associated with the laboratory, of whom the author was a member. Others who contributed substantially to the success of the project included O. W. Lang, H. Betts, F. Yerman, and C. Beck. Even though the various factors are interrelated, they will be discussed separately, as far as possible, in order to simplify the presentation.

## REFRIGERATION AS SPOILAGE PREVENTIVE

Other more objective means, in addition to the organoleptic one, were sought as indices of the spoilage-preventive effects of the various storage temperatures. In this search all the likely chemical methods which had been reported were tried in the early, somewhat groping, efforts on the project. In Tables 1 and 2 are shown the results of the first experiment with tuna stored at various temperatures and in ice. As an additional index of the condition of the fish, the vent of the retort in which the tuna were precooked was connected to a water condenser to collect any volatile substances in the vapors which escaped during the precooking operation. It can be seen, judged organoleptically and by some of the chemical criteria, such as carbonyl compounds, that ice and 3.5% salt at 30° F. are limited in their preservative action when compared to that at lower temperatures such as 22° and −5° F. The results of a second more extensive series of experiments are recorded in Tables 3, 4 and 5. In this set tuna were placed in various warm brines at room temperature and in brines precooled to the respective storage temperatures. In order not to overlook any possible means of evaluating the condition of the fish, the precooker gases not condensed by passage through the condenser attached to the vent were trapped in distilled water. The results for the content of these precooker vapors are shown in Table 5. Here again 30° F. was shown to be restricted in its long-range spoilage preventive capacity for tuna; temperatures of 22° F. or lower were able to prevent spoil-

[a] Based on a paper presented at the Fourteenth Annual Meeting of the Institute of Food Technologists, June 27, 1954, Los Angeles.

**TABLE 1**

**Various spoilage products in Bluefin tuna stored in brines at various temperatures and in ice [1]**

| Storage temperature °C. | °F. | Brine Concentration % | Indole [2] Loin | Belly | $H_2S$ [2] Loin | Belly | Ammonia [4] Loin | Belly | Trimethylamine [4] Loin | Belly | Carbonyl compounds [2] Loin | Belly |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| —1.1 | 30 | 3.5 | 0.3 | 3 | 0 | 0 | 9.5 | 10.3 | 0 | 0 | 55.5 | 248.6 |
| —5.6 | 22 | 10.5 | 1.5 | 3.3 | 0 | 0 | 7.5 | 5.2 | 0 | 0 | 44.1 | 107.6 |
| —20.6 | —5 | 23 | 6 | 0.2 | 0 | 0 | 5.2 | 8.6 | 0 | 0 | 16.5 | 21.2 |
| —1.1 | 30 | Ice | 0.3 | 0.8 | 2.7 | .. | 10.7 | .... | 0.43 | .. | 56.0 | ..... |

[1] The fish at 30° F. in ice kept for 30 days, when they were in a spoiled condition; in brine they kept for 47 days. The others were held 50 and 57 days, respectively, and were still passable.
[2] Micrograms per 100 grams.
[3] Ml. 0.01 N Iodine consumed per 100 grams.
[4] Milligrams N per 100 ml. press juice.

age in tuna for much longer periods, the time depending upon the temperature.

From the chemical data presented it was obvious that none of the methods tried could serve as an accurate, reliable index of the condition of the fish compared to the organoleptic judgment. The most promising of them appeared to be the determination of carbonyl compounds. This observation, together with the facts

**TABLE 2**

**Analysis of precooker condensates from Bluefin tuna stored in brines at various temperatures**

| Storage temperature °C. | °F. | Indole [1] | $H_2S$ [1] | Volatile bases [2] | Volatile acids [2] | Carbonyl compounds [3] | Condition of fish |
|---|---|---|---|---|---|---|---|
| —1.1 | 30 | 12.2 | 0 | 135.4 | 28.3 | 313.4 | Not Passable |
| —5.6 | 22 | 0 | .... | 255.2 | 156.0 | 158.0 | Passable |
| —20.6 | —5 | 3.6 | 3.8 | 62.0 | 222.0 | 95.7 | Passable |
| —1.1 | 30-Ice | 224.2 | 10.6 | 430.7 | 435.9 | 321.1 | Not Passable |

[1] Micrograms.
[2] Milligrams N.
[3] Ml. 0.01 N.
[4] Ml. 0.01 N Iodine consumed.

that volatile substances were liberated from the fish during the precooking operation and that the odor of fish was the most widely used means of evaluating their freshness, was the stimulus to the subsequent development of the Volatile Reducing Substances (V.R.S.) method as a means of obtaining a quantitative measure of the condition of fish. This method is based on the determination of all the volatile oxidizable constituents and does not depend on the presence of any one class of compounds, such as volatile acids or bases or of indole, which are the products of the activity of specific kinds of bacteria, and not always responsible for a spoilage condition.

From the above results of the storage experiments on tuna at various temperatures and of other similar ones, certain observations for the practical refrigeration of tuna manifested themselves. These were incorporated in the design of the refrigeration system on a tuna clipper under construction at the time, in which for the first time brine refrigeration was the chief means of preserving the catch at sea. Figures 1 and 2 illustrate the

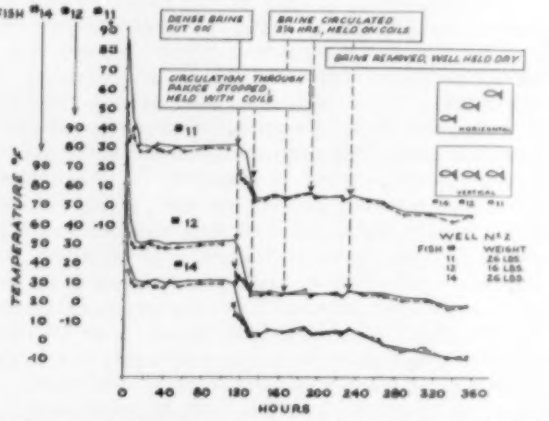


**Figure 1. Chilling and freezing of tuna on board the first tuna clipper built incorporating the laboratory findings on tuna refrigeration.**

course of the temperature changes of tuna in 2 separate storage wells on the vessel. Chilled seawater at slightly below 30° F. was used to initially cool the fish, which required between 10 and

**TABLE 3**

**Various spoilage products in Bluefin tuna stored in brines at different temperatures [1]**

| Storage temperature °C. | °F. | Percent brine | | Per 100 ml. Press Juice: Total volatile nitrogen | Trimethylamine nitrogen | Volatile acids | Indole | $H_2S$ | Condition of fish |
|---|---|---|---|---|---|---|---|---|---|
| —1.1 | 30 | 3.5 | W [2] | 18.7 | 4.1 | 8.3 | 50 | 3.2 | Spoiled |
| | | | P [3] | 21.8 | 4.2 | 7.3 | 25 | 1.9 | |
| | | | E [4] | 34.6 | 4.5 | 3.3 | 50 | 2.4 | |
| —5.6 | 22 | 10 | W [2] | 12.9 | 3.2 | 6.7 | 0 | 0.8 | Passable |
| | | | P [3] | 21.0 | 3.4 | 11.3 | 12.5 | 0.6 | |
| | | | E [4] | 25.2 | 4.7 | 6.8 | 12.5 | 1.2 | |
| —12.3 | 10 | 17 | W [2] | 12.9 | 2.3 | 5.8 | 25 | 0.5 | Passable |
| | | | P [3] | 15.5 | 2.5 | 9.8 | 5 | 0.7 | |
| | | | E [4] | 23.0 | 3.6 | 7.9 | 5 | 0.7 | |
| —20.6 | —5 | 23 | W [2] | 8.2 | 2.9 | 6.5 | 25 | 0.6 | Passable |
| | | | P [3] | 14.0 | 2.6 | 9.2 | 5 | 0.7 | |
| | | | E [4] | 24.5 | 3.4 | 8.6 | 12.5 | 1.4 | |

[1] Fish in 3.5% brine at 30° F. were kept 48 days; others were kept 56 days.
[2] W—Warm fish cooled simultaneously with warm brine.
[3] P—Warm fish immersed in precooled brines.
[4] E—Warm fish in ice.

**TABLE 4**

**Various spoilage products in precooker condensates from Bluefin tuna stored 56 days in brine at various temperatures [1]**

| Substance | | Storage temperature and brine concentration | | | |
|---|---|---|---|---|---|
| | | 30° F. 3.5% | 22° F. 10% | 10° F. 17% | —5° F. 23% |
| Indole | W[2] | 280.0 | 1.25 | 1.25 | 1.25 |
| | P[3] | 75.0 | 1.25 | 1.25 | 0.63 |
| | E[4] | 600.0 | 3.76 | 2.50 | 1.25 |
| Volatile Bases | W[2] | 54.5 | 31.8 | 23.5 | 23.1 |
| | P[3] | 70.6 | 47.1 | 30.2 | 27.8 |
| | E[4] | 49.0 | 38.7 | 58.7 | 46.0 |
| Carbonyl Compounds | W[2] | 409.0 | 16.5 | 16.2 | 12.5 |
| | P[3] | 474.0 | 19.7 | 16.0 | 12.2 |
| | E[4] | 173.0 | 61.5 | 36.8 | 58.9 |
| $H_2S$ | W[2] | 1.1 | 0 | 0.14 | 0 |
| | P[3] | 1.6 | 0 | 0 | 0.5 |
| | E[4] | 1.8 | 0 | 0.3 | 0.4 |
| Volatile Acids | W[2] | 114.0 | 91.2 | 103.0 | 105.0 |
| | P[3] | 130.0 | 115.5 | 113.0 | 124.0 |
| | E[4] | 123.5 | 115.5 | 137.0 | 91.0 |

[1] Fish in 3.5% brines and ice were held only 46 days, when they were spoiled.
[2] W—Warm brine and fish cooled simultaneously.
[3] P—Warm fish immersed in precooled brines.
[4] E—Fish stored in ice at various temperatures.

12 hours to reach 30° F. The chilled seawater was recirculated through the well until it was filled with fish. The chilled seawater was then removed and the fish frozen by means of a concentrated brine of about 20% salt, which brought the temperature down to the range of 0° to 5° F. within about 18 hours. At that point some wells were held dry and cooled by means of the coils around the well, whereas others were maintained with recirculating dense cold brine. There was a greater tendency towards a fluctuation in temperature when the former condition was practiced (Figure 2). It may be of interest to mention that the maiden voyage of this tuna clipper equipped with the first brine refrigeration system lasted from October to December 1938, 88 days, with the oldest fish on board being 73 days. All were landed in good condition. This established a pattern and many tuna clippers were subsequently built with brine refrigeration systems. The limitations of ice as a refrigerating medium in the warm fishing areas came to be generally recognized and its use was largely restricted to vessels making rather short trips. Eventually, as these vessels are replaced, the use of ice for tuna vessels will no doubt be completely abandoned.

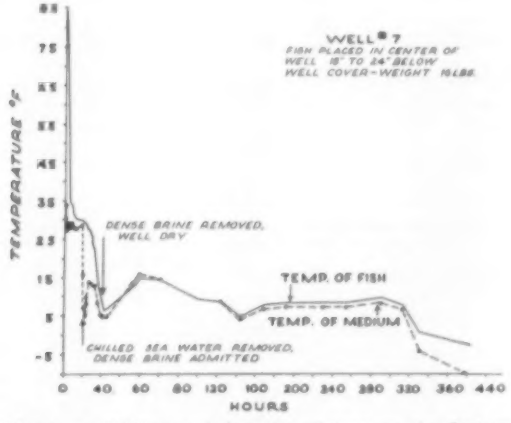
WELL # 7
FISH PLACED IN CENTER OF WELL 18' TO 24' BELOW WELL COVER—WEIGHT 15 LBS.
TEMPERATURE °F
DENSE BRINE REMOVED, WELL DRY
TEMP. OF FISH
TEMP. OF MEDIUM
CHILLED SEA WATER REMOVED, DENSE BRINE ADMITTED
HOURS

**Figure 2. Chilling and freezing of tuna on the first tuna clipper incorporating the laboratory findings on tuna refrigeration.**

**California sardines and similar fish.** As mentioned, the refrigerated storage of sardines and mackerel was studied both as a conservation measure and as a device to smooth out the usually uncertain working day in the sardine canneries. From many spoilage experiments at different temperatures a curve was constructed showing the relationship between temperature and storage time for fish in the round. This is illustrated in Figure 3.

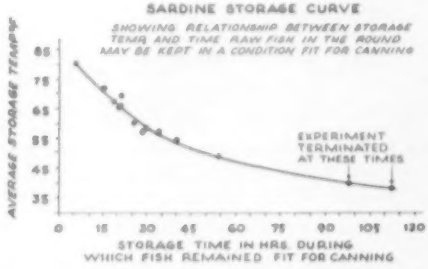
SARDINE STORAGE CURVE
SHOWING RELATIONSHIP BETWEEN STORAGE TEMP. AND TIME RAW FISH IN THE ROUND MAY BE KEPT IN A CONDITION FIT FOR CANNING
AVERAGE STORAGE TEMPS°F
EXPERIMENT TERMINATED AT THESE TIMES
STORAGE TIME IN HRS. DURING WHICH FISH REMAINED FIT FOR CANNING

**Figure 3. Relationship between storage temperature and time sardines can be kept in a condition fit for canning.**

It is to be noted that in the range of 35° to 40° F. such fish as sardines and mackerel can be kept in a condition fit for canning at least for 5 days and even up to a week.

To obtain an adequate chilling rate for the temporary preservation of sardines or mackerel a suggested brine refrigeration system able to maintain the fish in the range of 35° to 40° F. for many days is illustrated in Fgure 4. The suggested brine spreader on the bottom of each fish storage tank is a horizontal pipe (attached to the vertical brine inlet pipe of about 3 inches in diameter) running the length of the tank with 3 equally-spaced pipes attached to each side to form a sort of triple cross structure, each arm of the cross being about 3 feet long. This brine spreader system, just above the floor of the tank, should be perforated with holes in a staggered pattern, including the ends of each arm. Using such a brine chilling system as outlined above, the chilling rate shown in Figure 5 was obtained. There is a steady, rapid drop of the fish temperature throughout the tank to 40° F. within 3 hours.

In Figures 6 and 7 are illustrated the effects of increasing the brine circulation rate and of an uneven chilled brine distribution system in a tank; in both cases a slowing up of the chilling rate of the fish in the tank was observed. For an efficient system the

**TABLE 5**

**Various spoilage products in precooker uncondensed volatile gases from Bluefin tuna stored 56 days at various temperatures in brines [1]**

| Storage temperature | | Brine concentration | Volatile bases | | | Volatile acids | | | $H_2S$ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ° C. | ° F. | % | W[2] | P[3] | E[4] | W[2] | P[3] | E[4] | W[2] | P[3] | E[4] |
| —1.1 | 30 | 3.5 | 0.58 | 0 | 0 | 48.9 | 37.0 | 38.2 | 0.6 | 0.28 | 1.02 |
| —5.6 | 22 | 10 | 0 | 0 | 0.62 | 25.8 | 22.8 | 22.0 | 0.3 | 0.07 | 0.67 |
| —12.3 | 10 | 17 | 0.18 | 0.08 | 0 | 13.5 | 14.9 | 19.6 | 0.24 | 0.14 | 0.48 |
| —20.6 | —5 | 23 | 0 | 0 | 0 | 10.3 | 10.4 | 13.7 | 0 | 0.14 | 0.41 |

[1] Fish in 3.5% brine and ice were spoiled after 46 days.
[2] W—Warm fish simultaneously cooled with warm brine.
[3] P—Warm fish immersed in precooled brines.
[4] E—Warm fish stored in ice.

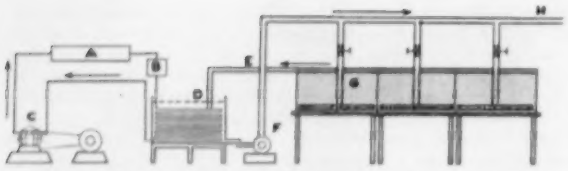


**Figure 4. A suggested brine chilling system for sardines and mackerel for their storage in the temperature range of 35 to 40° F.**

A—Ammonia condenser
B—Ammonia receiver
C—Ammounia compressor
D—Brine chilling tank showing coils
E—Chilled brine return
F—Brine pump
G—Sardine storage tanks
H—Chilled brine header system

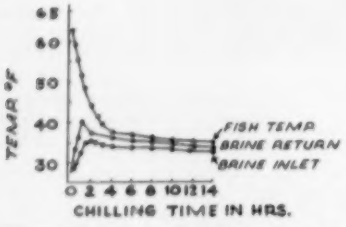


**Figure 5. Showing an efficient chilling curve for sardines.**

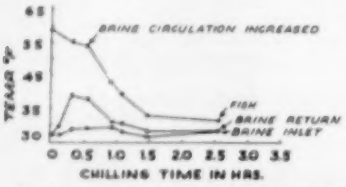


**Figure 6. Showing the change in sardine cooling rate with an increase in the rate of brine circulation.**

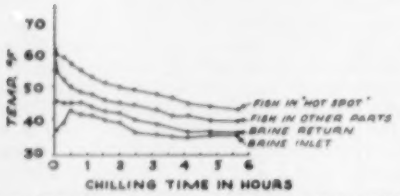


**Figure 7. Showing the effect of an uneven brine distribution in a tank on the chilling rate of fish at various parts in the tank.**

temperature of fish in all parts of the tank should reach 40° F. within 2 to 3 hours.

## SALT PENETRATION

One of the possible drawbacks of a brine-immersion refrigeration system which has been raised at various times is the penetration of salt into the flesh *(1, 9, 12)*. In order to determine the extent of this infiltration salt was determined in the skin and in successive ¼-inch layers below the skin in both tuna and sardines. Table 6 shows the amount of salt in bluefin tuna after a 30-day storage period in brines at various temperatures. These fish were placed in the brines at room temperature and then were refrigerated simultaneously with the brine. Even under these unfavorable chilling conditions it is evident that the salt penetration from the strongest brine was not much more than from the 10% salt brine. An indication of the advantage of prechilling the brine is seen from the results of the fish in 10% salt which were rapidly cooled by storage at —20° F. until the desired storage temperature was attained and were then transferred to a

**TABLE 6**

**Amount of salt in Bluefin tuna after 30 days in brines at various temperatures**

| Brine conc. % | Storage temperature ° C. | ° F. | Percent salt in Bluefin tuna sections: Skin | 1st ¼-in. flesh | 2nd ¼-in. flesh |
|---|---|---|---|---|---|
| 0-ice | —1.1 | 30 | 0.39 | 0.39 | 0.41 |
| 3 | —1.1 | 30 | 0.87 | 1.96 | 1.84 |
| 10 | —5.6 | 22 | 2.39 | 5.23 | 3.44 |
| 10 Rapidly cooled | —5.6 | 22 | 0.79 | 4.02 | 3.38 |
| 23 | —20.6 | —5 | 4.19 | 7.76 | 4.53 |

storage room at the same temperature. Tables 7 and 8 record the results of a more extensive series of experiments. Bluefin tuna were immersed in warm brines of various concentrations at room temperature and in prechilled brines at the desired storage temperatures, all being then stored at the respective storage temperatures. In Table 7 the maximum rates of salt increase per day are shown. It is evident that the salt penetration into the deeper layers is less at —5° F. than at higher temperatures, even though the brine concentration was much greater. The further minimization of the salt entry into the flesh by using a prechilled brine is also evident. The actual salt contents of the fish stored under the various conditions are shown in Table 8. Here again the advantage of low temperatures and of using a brine with a lower temperature than the fish may be seen. The

**TABLE 7**

**Salt penetration into Bluefin tuna from brines at various temperatures**

| Brine conc. % | | Temperature ° C. | ° F. | Maximum percent salt increase per day in: Skin | 1st ¼-in. flesh | 2nd ¼-in. flesh | 3rd ¼-in. flesh |
|---|---|---|---|---|---|---|---|
| 3.5 | W | —1.1 | 30 | 0.323 | 0.347 | 0.096 | 0.063 |
| | P | | | 0.094 | 0.124 | 0.041 | 0.057 |
| 10 | W | —5.6 | 22 | 0.356 | 0.463 | 0.275 | 0.076 |
| | P | | | 0.418 | 0.530 | 0.109 | 0.036 |
| 17 | W | —12.3 | 10 | 0.755 | 0.728 | 0.161 | 0.024 |
| | P | | | 0.644 | 0.234 | 0.108 | 0.033 |
| 23 | W | —20.6 | —5 | 0.593 | 0.342 | 0.038 | 0 |
| | P | | | 0.339 | 0.182 | 0.033 | 0 |

**TABLE 8**

**Sodium chloride in tuna after storage in brines**

| Storage temperature ° C. | ° F. | Brine conc. % | Percentage of sodium chloride in: Skin | 1st ¼-in. flesh | 2nd ¼-in. flesh | 3rd ¼-in. flesh |
|---|---|---|---|---|---|---|
| —1.1 | 30 | 3 warm | 2.20 | 2.86 | 2.35 | 1.78 |
| | | precooled | 2.40 | 2.40 | 1.96 | 1.44 |
| —5.6 | 22 | 10 warm | 5.65 | 6.92 | 5.11 | 1.81 |
| | | precooled | 5.27 | 6.56 | 4.08 | 0.99 |
| —12.3 | 10 | 17 warm | 5.75 | 8.60 | 2.90 | 0.37 |
| | | precooled | 4.71 | 8.10 | 2.71 | 0.36 |
| —20.6 | —5 | 23 warm | 7.90 | 7.36 | 0.46 | 0.08 |
| | | precooled | 6.22 | 4.04 | 0.23 | 0.04 |

practical test of the above observations is given in Table 9, showing the content of salt in tuna frozen under various conditions in brine on the tuna clipper which pioneered brine refrigeration. It will be noted that the salt contents are generally lower than those encountered in the laboratory experiments. The effect of temperature is clearly indicated in the fish from well No. 11, which were stored in a 20-22% salt brine-slush ice mixture at 22.5 to 25° F. The salt concentrations in the outer layers of the fish are higher in this case than in any of the others. It is thus clear that with strong brines low temperatures in the neighborhood of 0° F. must be used to prevent any appreciable salt penetration into the fish during freezing and storage.

**TABLE 9**

**Percentage of sodium chloride in Yellowfin tuna stored on board a tuna clipper**

| Well No. | Hours at 30° F. | Final storage conditions | Percentage of sodium chloride in | | | |
|---|---|---|---|---|---|---|
| | | | Skin | 1st ¼-in. flesh | 2nd ¼-in. flesh | 3rd ¼-in. flesh |
| 1 | 100 | Dense, brine, —5° F. | 4.97 | 1.35 | 0.56 | 0.17 |
| 2 | 103 | Dry, on coils, —5° F. | 3.33 | 1.54 | 0.49 | 0.08 |
| 3 | 98 | Dense, brine, 5° to 10° F. | 5.03 | 2.84 | 0.71 | 0.13 |
| 5 | 0 | Dry, on coils, 15° to 20° F. | 5.76 | 0.25 | 0.08 | 0.13 |
| 7 | 0 | Dry, on coils, —5° F. | 3.64 | 0.57 | 0.43 | 0.14 |
| 11 | 20 | Dense brine & slush ice, 22.5° to 25° F. | 5.01 | 3.23 | 0.82 | 0.06 |

Similar experiments to those for tuna were carried out with California sardines. Some representative data are recorded in Tables 10 and 11, showing the maximum rates of salt increase per day and total contents of salt in the sardines stored in increasing salt brines at decreasing temperatures. Here also the definite effect of temperature on the salt penetration is evident, as well as the advantage of using prechilled brines for the fish. The differences for the rather thin and small sardines are much more accentuated than they were for the much larger tuna, particularly when the maximum rates are compared. An interesting observation with respect to the relationship between salt penetration and temperature is presented in Figure 8, which shows an Arrhenius plot of the maximum salt increase per day and the reciprocal of the storage temperature.

From the above data it can be concluded that for any brine concentration a lowering of the storage temperature will result in a decreased salt transfer into the fish. Furthermore, with low initial brine and storage temperatures and adequate brine circulation, resulting in a rapid removal of heat from the outermost layers of the immersed fish, the penetration of salt into the flesh of fish can be kept at a minimum or at relatively insignificant levels.

This point is further emphasized by the data obtained from the analyses of tuna delivered to canneries by various fishing vessels. The first set of 23 determinations was made on fish which had been subjected to an initial chilling in cold seawater at about 30° F. followed by an immersion in a cold, strong brine to freeze them. The average salt contents in the first and second ¼-inch layers of the fish were 0.82 and 0.30% respectively. The second set of 32 determinations was made on fish which had been chilled in cold seawater, followed by the addition of salt to the same seawater with the simultaneous lowering of the temperature to the range 22° to 25° F. The average salt contents in the first and second ¼-inch layers of the flesh were 2.35 and 1.11%, respectively. A third set of 6 determinations was made on fish which had been placed directly into 12% salt brine at 18° F. The average salt contents for the first and second ¼-inch layers were 1.68 and 1.34%, respectively. The increased salt content in the second and third sets compared to the first set is noteworthy and bears out the remarks made above.

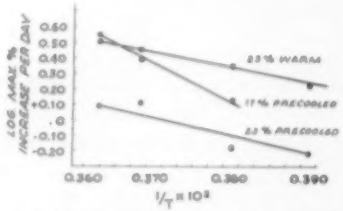


**Figure 8. Showing the relationship between salt penetration into sardines and storage temperature as an Arrhenius plot.**

## CHANGES IN FISH, OTHER THAN THOSE OF SPOILAGE, IN RELATION TO TEMPERATURE

In addition to salt penetration and spoilage from inadequate refrigeration, other changes can occur in fish muscle which will adversely affect the subsequent quality of the product, including such factors as flavor and texture. One of the most important changes which can occur is protein denaturation with the concomitant effect on texture and flavor. It has been shown by various investigators *(3, 4, 11, 13, 14)* that, for such fish as haddock, halibut, and cod, the temperature zone ranging between 30° and 23° F. is a critical one with respect to the formation of drip and alterations in texture and flavor. The longer the fish remain in this temperature zone the larger the ice crystals become, the greater the loss of intracellular fluid and of flavor,

**TABLE 10**

**The maximum rate of salt increase in sardine flesh from increasing concentrations of brine at various temperatures**

| Storage temperature ° C. | ° F. | Maximum percent salt increase per day in | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 3% Brine | | 12% Brine | | 17% Brine | | 23% Brine | |
| | | W[1] | P[2] | W[1] | P[2] | W[1] | P[2] | W[1] | P[2] |
| —1.1 | 30 | 0.766 | 0.346 | 2.25 | 1.75 | 4.32 | 3.46 | 3.24 | 1.24 |
| —5.6 | 22 | ..... | ..... | 1.39 | 0.885 | 2.60 | 2.43 | 2.78 | 1.26 |
| —13.3 | 8 | ..... | ..... | ..... | ..... | ..... | 1.40 | 2.10 | 0.65 |
| —20.6 | —5 | ..... | ..... | ..... | ..... | ..... | ..... | 1.60 | 0.59 |

[1] W—Fish immersed in warm brine.
[2] P—Fish immersed in precooled brine.

**TABLE 11**

**Salt content of California sardines after brine storage**

| Brine concentration % | Percent salt in sardines after 21 days storage at ° F. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Skin | | | | Flesh | | | |
| | 30 | 22 | 8 | —5 | 30 | 22 | 8 | —5 |
| 3 precooled | 1.29 | ..... | ..... | ..... | 1.18 | ..... | ..... | ..... |
| warm | 1.25 | ..... | ..... | ..... | 1.58 | ..... | ..... | ..... |
| 12 precooled | 7.28 | 2.11 | ..... | ..... | 8.34 | 8.00 | ..... | ..... |
| warm | 10.30 | 4.94 | ..... | ..... | 8.34 | 8.00 | ..... | ..... |
| 17 precooled | 8.10 | 6.40 | 3.05 | ..... | 8.65 | 11.15 | 3.98 | ..... |
| warm | 9.07 | 8.00 | 6.75 | ..... | 10.16 | 11.20 | 7.39 | ..... |
| 23 precooled | 7.06 | ..... | 7.72 | 3.90 | 9.85 | 9.37 | 8.24 | 1.37 |
| warm | 9.16 | ..... | 10.85 | 4.35 | 14.95 | 9.44 | 12.70 | 2.92 |

and the more adverse the changes in texture that occur. Some experiments were carried out on tuna and sardines to determine whether such changes also occur in them, particularly with respect to protein denaturation. Figures 9 and 10 show the amount of protein denaturation, as measured by the soluble protein nitrogen in press juices, in tuna stored at several temperatures. The marked decrease in protein denaturation on lowering the temperature from 30° to —5° F. (Figure 9) is of interest. Furthermore, it is to be noted that below 10° F. the further decrease in amount of denaturation is small compared to that occurring

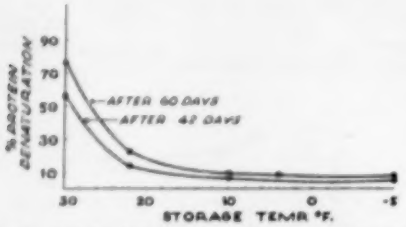


**Figure 9. Protein denaturation in tuna during storage at various temperatures.**

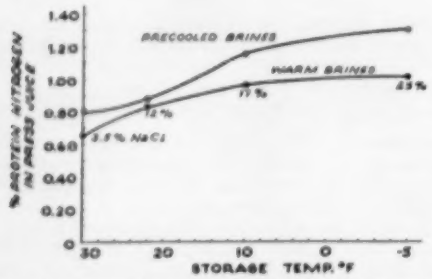


**Figure 10. Changes in soluble proteins in bluefin tuna stored 48 and 56 days in warm and precooled brines at 30° and lower temperatures, respectively.**

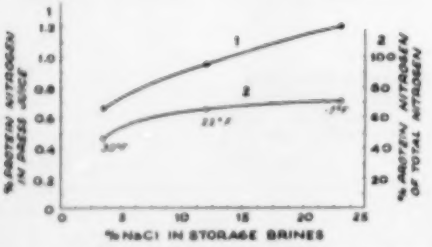


**Figure 11. Changes in soluble proteins of sardines stored 2 days in precooled brines at 30°, 22° and —5° F.**

above this temperature. In Figure 10 the changes in soluble protein in tuna stored in warm and precooled brines are shown. The changes in soluble proteins in sardines after storage at various temperatures are shown in Table 12. It is to be noted that

**TABLE 12**

**Changes in globulins of sardines stored 22 days at various temperatures**

| Storage temperature ° F. | Mg. globulin nitrogen per 100 ml. press juice |
|---|---|
| 40 | 2. |
| 30 | 10. |
| 20 | 130. |
| 10 | 164. |
| —5 | 222. |

the amount of globulins or water-insoluble proteins decreases markedly as the temperature increases from 5° F. to 40° F., particularly above 20° F. Figure 11 shows the changes in soluble protein nitrogen in sardines stored 2 days in brines at various temperatures. The effect of temperature on the protein content is again to be seen.

## DISCUSSION

From the data presented above certain observations can be made relative to the use of refrigeration for preserving tuna, sardines, and mackerel. If the mere prevention of bacterial spoilage is considered, temperatures of about 20° F. and lower for tuna and 40° F. for the temporary storage of sardines will suffice. These temperatures can be obtained by immersion in refrigerated brines. However, when the other effects associated with refrigeration by cold brines are taken into consideration, these ranges, especially for tuna, have to be revised.

The still appreciable salt penetration occurring at temperatures from 30° to 20° F. and the significant protein denaturation proceeding in the same range make it important that the tuna should rapidly pass through this range to prevent as much salt infiltration and protein denaturation as possible. The flavor and texture will thereby be preserved as far as practicable in a state similar to that present in the starting material.

From a review of all the data presented and taking into consideration certain basic refrigeration principles, the following recommendations are suggested as minimum refrigeration requirements for practical operation of refrigeration on tuna vessels:

1. The tuna should be chilled in precooled seawater at 29° to 30° F. until an individual well or compartment is full, the brine being maintained at as constant a temperature as possible. After the well has been filled with fish, holding them in the chilled seawater at this temperature for a period of 24 hours will help to remove appreciable amounts of blood and thereby tend to lighten the subsequent color of the meat.

2. After this storage period, the chilled seawater containing blood and slime from the fish should be thoroughly removed and a precooled strong brine of 20 to 23% salt at 0° to —4° F. (depending on the salt concentration) should be added. An adequate circulation rate, such as 10 gallons per minute per ton of fish, should be maintained to freeze the fish as rapidly as possible to within the temperature range of 0° to 10° F., the latter being the maximum temperature at which the frozen fish should be held for any period of time.

3. The fish should be held at least 48 hours in the continuously circulating cold strong brine after a temperature of 10° F. or below is attained. The strong brine can then be removed for reuse in other wells; the fish in the compartment being held dry at a controlled coil temperature no higher than 10° F., and preferably lower, by means of an adequate back pressure regulating valve.

To increase the refrigeration capacity a slush ice source may be incorporated into the refrigeration system. Slush ice could also be used on boats for the chilling of such fish as sardines, mackerel, and herring. For the refrigeration of these rather small fish at sea the first

step in the above procedure could serve the purpose. The circulated chilled seawater or seawater with added salt could be used to preserve these fish at sea for the usual length of the voyages. The aforementioned slush ice would thereby fit in very well, since it would supplement the capacity of the refrigeration machinery.

The test of the proper use of any refrigeration system can be considered to be the production of a product similar to the original unfrozen material in flavor and texture. For example, if too high temperatures are used during the brine immersion, proteins will be extracted by the brines with the production of undesirable flavor and texture changes in the fish. A survey of brines used to freeze fish on the boats showed that the total brine on board a tuna boat contained an average protein nitrogen equivalent to from 935 to 2185 pounds of protein. The fish muscle as landed contained less protein than it should have had. Aside from the economic aspects of this loss, it represented a decrease in flavor and a change in texture in the final product.

## SUMMARY

The refrigeration of tuna, sardines, and mackerel by salt brines has been discussed from the points of view of spoilage prevention, salt infiltration, and protein denaturation. The practical application of the laboratory data has been tested on board a tuna clipper. Based on the available information certain recommendations have been suggested for the practical use of brine refrigeration for tuna, sardines, mackerel, and herring on board fishing boats.

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# Taste Comparisons: Two Samples or Three?[a,b]

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**Three common experimental designs for the detection of small differences in the intensity or quality of two flavors are: pair tests (which is the stronger? or, which is the regular flavor?); duo-trio tests (which of the two coded aliquots is identical with the third "standard" aliquot?); and triangle tests (which of the three aliquots is odd?). A balanced experiment to test the relative power of the designs is described. Six subjects made 18 replicate parallel trials of the three methods on two slightly different samples of each of three materials, namely: mixed primary flavors in water; tomato juice; and ground beef. The results suggest that pair tests and triangle tests are normally about equally powerful and appreciably superior to duo-trio tests.**

No simpler, and perhaps no commoner, item appears on the job card of a taste panel than the comparison of two similar samples. For instance, pursuit of uniform quality in a product often poses the question, "Is A distinguishable from B?" The flavor difference is presumed small enough to be sensed only with difficulty (otherwise there is no problem!), necessitating repeated judgments by each panel member, the proportion of correct judgments being the evidence on which decision is based. Let us consider how best to present the samples to the taster so that a reliable answer is obtained with a minimum of effort. More particularly, we shall discuss three well-known and easily handled arrangements (experimental designs), namely: the pair test, the duo-trio test, and the triangle test (the last two being collectively called triad, or 3-aliquot, tests). Choice of design has been dealt with by several authors, but these three tests seem nowhere to have been compared as thoroughly as their practical importance merits. Hopkins and Gridgeman *(3)* have recently explored the matter in some detail, and the reader is referred to their paper for a formal statistical treatment of the work reported here.

The *pair test* involves simultaneous presentation of one coded aliquot each of samples A and B with the question, "Which is the . . . er of the two?" or "Which is the regular sample?" The first question requires an appropriate comparative adjective, such as *sweeter* or *blander* or *spicier*, and the more complex the samples, the more complicated will both the framing and the answering of the question be. The second question, although demanding acquaintance with the taste characteristics of the normal product, is less ambiguous. In theory, a third question, "Which do you prefer?" is usable, but is not particularly to be commended when difference and not preference *per se* is at issue. Tasters may well have conflicting preferences, so that the pooling of panel judgments could be misleading. The only safe procedure would be to assess the probability of a difference separately for each member and then to combine the probabilities. This makes the test at once more complicated and less searching than otherwise.

In the *duo-trio test*, three aliquots, two of A with one of B, or one of A with two of B, are presented. One of the duplicates is coded, say, S, and the other aliquots are coded, say, 1 and 2, and the question asked is "Either 1 or 2 is identical with S; which is it?" This situation calls for discrimination only. The probability of the correct answer's being elicited by chance is, as in the pair test, one in two.

In the *triangle test*, the presentation is exactly as in the preceding design, but the coding is linear, say, 1, 2 and 3, and the question runs, "Two members, and two only, of this triad are identical; which are they?," or, "Which is the odd sample?" This again is simple discrimination, but the probability of a chance correct answer is only one in three.

It is probably fair to say that the pair test seems at first sight to be less satisfactory than either of the 3-aliquot tests. More specifically, the triangle test has been labeled *(2)* "obviously more efficient" than the pair test on the ground that, for a panel of given size, the number of correct "triad" answers needed to detect a certain difference at a chosen level of statistical significance is smaller than the corresponding number of "pair" answers, but it is not clear what definition of efficiency is implied.

On the other hand, Byer and Abrams *(1)* have submitted evidence in favor of the pair test. Their experimental results (on solutions of dextrose and of quinine sulfate) were assessed on the following basis: The numbers of correct results above chance expectation were measured in units of the standard deviation, "as with panels that are fairly large and of about the same size, equivalent deviations in $\sigma$ units correspond closely to equal probabilities of occurrence of results by chance, the greater the deviation, the smaller being the probability that the results reflect chance variation and the greater being the significance attached to the tasters' discrimination." Because the 2-aliquot tests gave more significant results, in this sense, than the 3-aliquot tests, the conclusion was drawn that the former were the more discriminating.

## SOME THEORETICAL ASPECTS

The probability that a certain subject, tasting a particular pair of samples presented in one of the three described designs, gives the correct [c] answer, is a specific quantity $p$. Here $p$ is the limit of the ratio R/N, where R is the number of correct judgments in N trials, as N becomes very large. Clearly, $p$ is not a simple probability, for its lower limit is not zero but 1/2 (for pairs

[a] Manuscript received July 12, 1954.

[b] Contribution from the Division of Applied Biology, National Research Laboratories, Ottawa, Canada. Issued as N. R. C. No. 3533.

[c] There is of course no "correct" answer to the preference question that can be used for pair test, but this does not affect the argument.

and duo-trios) or 1/3 (for triangles), these being the proportions of correct judgments that would be obtained in the long run on indistinguishable samples. In fact, $p$ is a blend of two probabilities: $p_d$, that of correct discrimination, and $p_g$, that of a lucky guess. Because $p_g$ can operate, as it were, only on what is left from $p_d$, we have,

$$p = p_d + p_g (1 - p_d)$$

in which $p_g$ is always known *a priori*. Hence,

$$p = (1 + p_d)/2 \text{ for pairs and duo-trios}$$

and $$p = (1 + 2p_d)/3 \text{ for triangles.}$$

Even if $p_d$ were uninfluenced by design, it is by no means obvious which of these equations is the "better," for $p$ itself is not a measure of the ability of a test to distinguish between nearly identical samples. In practice, moreover, there is no reason to assume that $p_d$ is independent of design, and what differences obtain may themselves depend on the taster, the material tasted, and the magnitude of the taste difference. It follows that any attempt to assess relative merits must rest on experimental estimates of $p_d$ for each design under the same conditions.

Having estimated $p_d$, we then need a criterion of *merit*. This is best met by the statistically precise concept of *power*, defined, in this technical sense, as the probability of correctly rejecting, at some predetermined significance level, a false null hypothesis. Here, the null hypothesis will be "no difference between samples A and B," and the power will be the probability of detecting a real taste difference. Power depends on $p_d$, on the number, N, of replicate judgments, and on the chosen significance level. Following convention, we shall use the 5% level, i.e., we shall assert the existence of a real difference whenever the chance of its being fortuitously indicated is less than one in 20 (and we know that of every 20 such decisions, one will be wrong). Under these conditions power ranges from a minimum of 0.05 (detection unfeasible) to unity (detection infallible).

Figure 1 illustrates power in more detail. The necessary calculations are discussed in several statistical texts; see, for example, Kenney and Keeping *(4)*. It is to be noted, incidentally, that the smooth curves of normal distribution in Figure 1 are strictly applicable only when N is large; for small experiments, the exact binomial frequencies must be used. Some representative power curves are given in reference *(3)*, where it is shown that if $p_d$ were the same for each design the triangle test would almost invariably be the most powerful.

One further step may be taken. From the estimates of $p_d$ and the corresponding powers, we may predict the number of single trials needed to yield a test of any given power. Therefore the designs may be compared on a "cost" basis, i.e., as relative amounts of tasting required to achieve a result of a certain significance.

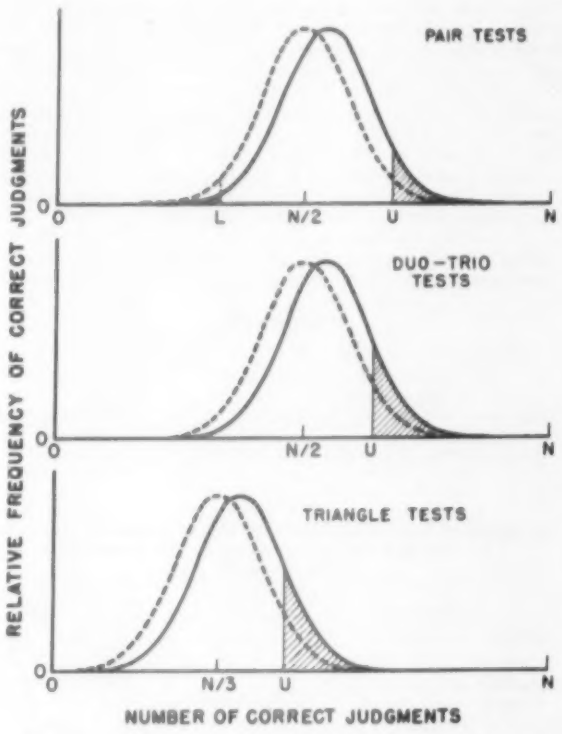


**Figure 1. Full curves: actual frequency distribution of R, the number of correct judgments in N trials, for a particular (discriminated) taste contrast.**

**Dash curves: judgment distribution for undetectable contrast (the null hypothesis).**

**Hatched area (as fraction of full-curve areas): power of the test (the power obviously depends on the displacement between the full and dash curves, which in turn depends on $p_d$—see text).**

**L and U: are the lower and upper limits (read from tables of the normal distribution) at, say, $P = \alpha$, beyond which the null hypothesis will be rejected. For pairs, both L and U, each placed at the point $P = \alpha/2$, will be needed; but for duo-trio and triangle tests, only U, placed at the point $P = \alpha$, is concerned (because here, correct judgments significantly below the null hypothesis cannot, whatever else they may mean, be indicative of discrimination).**

## EXPERIMENTAL

Three materials of widely different flavor complexity were chosen. The first was a mixture of primary flavors: 1 part of quinine sulphate, 175 of tartaric acid, 500 of sodium chloride and 3125 of sucrose. Two aqueous solutions were prepared for tasting, the stronger containing 0.57%, and the weaker 0.51%, of this mixture. They were served at 70° F. The question for the paired comparisons was, "Which is the stronger?"

The second material was canned tomato juice. To differentiate 2 samples, a bulk quantity was boiled for 2 minutes, cooled, and then mixed with an equal quantity of untreated juice. For the paired comparisons the question was "Which is the normal, untreated, sample?" Servings were made at 60° F.

The third material, ground beef containing 13% fat and 0.5% added sodium chloride, was shaped into 4-oz. patties, broiled for 20 minutes at 450° F. and served hot. Sample differentiation was effected by the mixing of 0.4% monosodium glutamate in half of the uncooked meat. The question for the pairs was, "Which has the stronger flavor?"

A panel of 6 tasters was used. Each subject made 18 replicate judgments, so that the total number was 6 x 18 x 3 x 3 = 972. The work was spread over 27 sessions (two per day) in such a way that only 2 designs, but with all 3 materials, were compared at any one session. Allocation of sets of two designs (9 each of pair: duo-trio, pair: triangle, and duo-triangle) was

randomized, with the restrictions that (a) each group of 3 sessions (chronologically, from the beginning), included all possible sets, (b) no design was ever immediately repeated along the time scale, (c) no one set of 2 designs was ever so repeated and (d) within sets, the alternative orders of presentation were as nearly balanced as possible. Within each design all possible arrangements under the codes (2 in the 1-2 code for pairs; 4 in the S-1-2 code for the duo-trio; 6 in the 1-2-3 code for the triangles) were represented as nearly equally as could be arranged. These intra-design arrangements were independent for each design so that no one session had a common pattern.

To exclude any "settling down" effect on discrimination, two initial dummy sessions were run. The tasters were unaware that the experiment proper did not begin until the third session.

## RESULTS

The distribution of the 538 correct judgments was examined for time trends, and for significant differences between the taster's individual judgments *(3)*. No heterogeneity of either kind being evident, the judgments in each of the 9 main groups could justifiably be summed over tasters. The summations are set out in Table 1 together with the derived estimates of $p_d$.

**TABLE 1**

**Numbers of correct judgments, R, out of a possible maximum of 108, and derived estimates of the probability of discrimination, $p_d$**

| Kind of test | Mixed flavors | | Tomato juice | | Minced beef | |
|---|---|---|---|---|---|---|
| | R | $p_d$ | R | $p_d$ | R | $p_d$ |
| Pair | 75 | 0.39 | 61 | 0.13 | 72 | 0.33 |
| Duo-trio | 65 | 0.20 | 58 | 0.07 | 66 | 0.22 |
| Triangle | 50 | 0.19 | 38 | 0.03 | 53 | 0.24 |

Inspection of the estimates of $p_d$ suggests, firstly, that the 2 kinds of triad do not differ in this respect, and secondly, that $p_d$ for the pairs is uniformly higher. Statistical significance tests confirm this. It may be shown that the variance of a "pair" or "duo-trio" $p_d$ is estimable as $4R\ (N - R)/N^3$, and that of a "triangle" $p_d$ as $9R\ (N - R)/4N^3$. This leads to the finding that the mean $p_d$ difference (0.01) between a duo-trio test and a triangle test is less than its standard deviation (0.07) and therefore not significant. On the other hand, the mean difference (0.125) between the $p_d$ of the pair test and the combined $p_d$ of the 2 triad tests is nearly twice its standard deviation (0.0635) and therefore significant at the 5% probability level. This latter $\Delta p_d$ will be used to calculate powers and costs.

## POWERS AND COSTS

Consider a pair test, replicated N times, having a probability of discrimination $p_d$, and a power P. On the basis of the present findings the comparable probabilities for duo-trio and triangle tests would both be $p_d$ *minus* 0.125. From this value the numbers of replicates needed to give either triad test a power P can be calculated. Suppose the results are xN for the duo-trio and yN for the triangle. The factors x and y will then be "costs," i.e., they will be the proportional increase (or decrease) of replication involved in a switch from pairs to the respective *equipotent* triads. As triads require the preparation and tasting of 50% more aliquots than do pairs, it can be argued that 1.5x and 1.5y are more realistic costs. Truth probably lies somewhere between these alternatives.

Cost calculations on both bases are plotted in Figure 2 for various N and $p_d$. In these circumstances it appears (i) that the duo-trio test is the least economic, and (ii) that the pair test, at least on an aliquot-for-aliquot basis, is usually the most economic. As N increases, triad tests become relatively more costly.

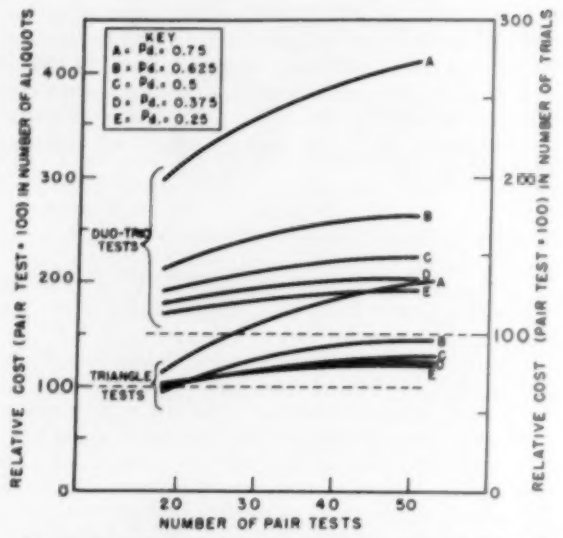


**Figure 2. Relative cost of equipotent pair and triad tests for various values of $p_d$ (probability of discrimination in pair test) and specified numbers of replicated pair tests.**

## DISCUSSION

The curves in Figure 2 do not allow exact prediction of specific relative costs because $p_d$ cannot be foreseen, and $\Delta p_d$ cannot be assumed to take the values found in the present investigation. Nevertheless they provide a general indication of cost trends in the area of applicability of the present findings.

Byer and Abrams *(1)* concluded that pair tests were superior to triangle tests—a consequence, mainly, of their dealing with a $\Delta p_d$ (pairs *minus* triangles) slightly larger than that reported here. Their mean value was 0.18; this is not necessarily in discord with the present estimate of 0.125, for $\Delta p_d$, even apart from its possible dependence on materials, subjects, etc., is difficult to evaluate accurately. The two investigations agree that triad tests are not normally superior to pair tests—provided, always, that the "pair" question is framed unambiguously. It is perhaps surprising that the duo-trio test, an attractive design on paper, should turn out in this investigation to be the least economic but these are not the first experimental findings to belie an intuitive conclusion.

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# Aureomycin[a] Chlortetracycline and the Control of Poultry Spoilage[b]

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**The use of Aureomycin to control poultry spoilage has been investigated. It was found that a solution containing a few p.p.m. of this antibiotic was effective in keeping cut-up or whole eviscerated chickens fresh and edible for a significantly longer time than was the case with untreated controls.**

The control of food spoilage is a major economic problem and is important from the standpoint of public health. With the continued success of antibiotics in controlling many microorganisms pathogenic to man, the application of antibiotics to control food-spoilage organisms suggests itself. In 1946, Curran and Evans *(1)* evaluated penicillin as a preservative for milk, but, from their study, concluded that penicillin had no application in the preservation of food. Other antibiotics, such as subtilin, gramicidin, bacitracin and streptomycin, have been investigated, particularly in the canning industry, but have been shown to be only partially successful. Recently, a number of studies have appeared, demonstrating that Aureomycin is markedly effective in retarding spoilage in fish and meat. Deatherage and co-workers, in a series of papers *(2, 3, 4, 5, 6)* have shown that the infusion of Aureomycin may prevent deep spoilage in beef carcasses where refrigeration is delayed. They also pointed out that Aureomycin rapidly disappeared in beef tissue during storage and that no adverse effect was noted when such meat was consumed. Tarr and co-workers came to similar conclusions with fish *(7, 8, 9, 10)*. They noted that the bacterial spoilage of whole eviscerated fish was retarded significantly by chilling with ice containing 1 to 4 p.p.m. of Aureomycin, by holding fish 6 days at —1° C. in sea water containing 2 p.p.m. of Aureomycin or by a brief immersion in 50-100 p.p.m. solution of Aureomycin prior to icing. More recently, Farber *(11)* described the preservative action of Aureomycin on a number of fish and shellfish.

Poultry is a perishable food item and presents a considerable problem to the producer and the consumer, even under the most ideal conditions. Ayres *et al. (12)* found that the development of off-odor and slime on the surface of cut-up chicken was largely associated with the growth and coalescence of colonies of several species of *Pseudomonas*. Other workers found a heavy load of microorganisms on the surface of commercial, eviscerated poultry *(13)*. Coliform organisms were especially prevalent and of 186 other strains isolated, representatives of 19 different genera were found *(14)*. In the present study, the use of Aureomycin to control poultry spoilage was considered. It was found that when cut-up or whole eviscerated chickens were processed with a solution containing a few p.p.m. of Aureomycin, such chickens remained fresh and edible significantly longer than untreated controls.

## METHODS

**Estimation of spoilage.** Poultry processed as described in the text were withdrawn at intervals from cold storage, judged organoleptically, and then the approximate number of microorganisms on the surface of the poultry were counted by the conventional *pour plate* technique. Whole or cut-up chickens were dipped in sterile distilled water (1 liter/chicken). All experimental chickens used weighed approximately 1 kilogram, so the number of microorganisms per ml. of rinse water was equivalent to the number of microorganisms per gram on a total weight basis. After a 5-minute soaking, each sample was dipped an additional 10 times and then discarded. Rinsings from birds processed with Aureomycin did not contain detectable amounts of Aureomycin. Appropriate dilutions were then made of these rinsings and added to pour plates containing nutrient agar. The plates were incubated at 23° C. for approximately 40 hours and then counted on a Spencer colony counter. Microscopic examination of the colonies confirmed the presence of bacteria; under the described conditions of cold storage, few yeasts or molds were encountered.

**Estimation of Aureomycin in poultry tissues.** Aureomycin in tissues of chickens was measured by the pad plate assay technique described by Grady and Williams *(15)* following the modifications of Broquist and Kohler *(16)*.

## RESULTS

Preliminary experiments indicated that Aureomycin not only markedly decreased the growth of microorganisms found on the surface of spoiling chicken but was the most effective among several antibiotics tried. A typical experiment is shown in Figure 1. A whole eviscerated chicken was obtained from a local retail market and allowed to spoil by letting it stand at room temperature for 2 days. The microorganisms on the surface of the chicken were washed off as previously described, diluted $1 \times 10^6$ times, and plated into nutrient agar containing various test antibiotics. In the absence of antibiotics (Figure 1), the control plate was overrun with organisms. There was essentially complete suppression of growth of all organisms in plates containing Aureomycin. Streptomycin, neomycin, chloramphenicol, and magnamycin were considerably less effective. Bacitracin, procaine penicillin, erythromycin, polymyxin B, and actidione had no effect in suppressing growth of the microorganisms from the spoiled flesh.

These data encouraged further work with Aureomycin to control poultry spoilage. To get a practical measure of the effectiveness of Aureomycin, a number of experiments were conducted in which cut-up poultry obtained from a local market were dipped in Aureomycin solutions of varying concentrations for 30 minutes at room temperature. The poultry parts were then wrapped separately in Kordite bags, stored at 3° C., and examined at weekly intervals. Typical results are in Table 1. In experiment 1 after one week's storage, the untreated controls (0 $\gamma$ Aureomycin per ml.) were obviously spoiling as evidenced by a strong odor and a bacterial count approaching $10^7$ organisms/g., whereas poultry dipped with Aureomycin as little as 3 $\gamma$ /ml. were fresh and edible and had 100-fold less microorganisms per g. of tissue. At the end of 2 weeks a dip of 10-30 p.p.m. of Aureomycin gave complete preservation; at 21 days

[a] The trademark of the American Cyanamid Company for the antibiotic chlortetracycline is Aureomycin.

[b] Presented at the Fourteenth Annual Meeting of IFT, Los Angeles, California, June 28, 1954.

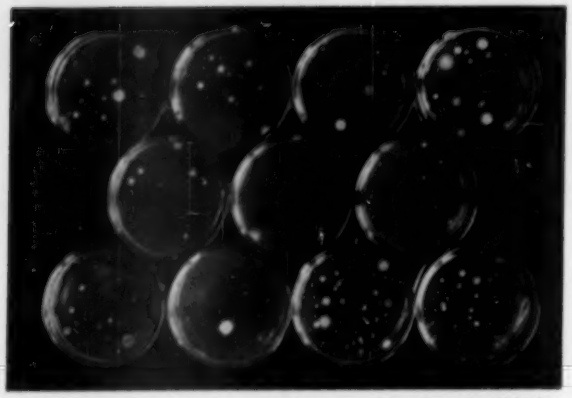

**Figure 1. Comparative effectiveness of various antibiotics in inhibiting growth of microorganisms from spoiled poultry. Reading from left to right, the antibiotics added per ml. medium are:**
**Top row: None; chloramphenicol (10γ), erythromycin (10γ), proc. penicillin (10γ).**
**Middle row: Neomycin (10γ), Aureomycin chlortetracyline (10γ), streptomycin (10γ).**
**Bottom row: Magnamycin (10γ), polymyxin B (100 units), bacitracin (11 units), actidione (10γ).**

while 10 p.p.m. appeared borderline, 30 p.p.m. of Aureomycin was still effective in prolonging the shelf life of the poultry meat. This is also shown in experiment 2, Table 1. Experiments with whole eviscerated chickens gave similar results.

To determine the influence of temperature on uptake of Aureomycin, an experiment was conducted in which chicken breast muscle was immersed in a solution of Aureomycin (100 p.p.m.) for various times at different temperatures. The amount of antibiotic in the muscle was then determined microbiologically. The experiment is summarized in Table 2. More Aureomycin was found in the muscle that had been dipped in the solution of Aureomycin at 3° C. than in muscle dipped in solutions at the higher temperatures. This indicates that the most efficient processing of poultry with Aureomycin would be at lower temperatures. When the chicken muscle was allowed to remain in the Aureomycin solution for a longer time period, the Aureomycin in the muscle increased somewhat.

The amount of Aureomycin in chicken muscle following immersion of the meat in various concentrations of antibiotic and the rate of destruction of the antibiotic in the meat during cooking were determined. Chicken breast muscle was dipped for 15 minutes at room temperature in Aureomycin solutions ranging from 3 to 1,000 γ/ml. The amount of antibiotic absorbed by the muscle increased in rough proportion to the concentration of Aureomycin in the dipping solution (Table 3, line 1). No antibiotic was found in meat boiled for 15 minutes, or roasted for 30 minutes following dipping in solutions containing 3, 10 and 30 γ/ml.; these strengths are effective in preserving poultry (Table 1). Even at the highest concentration tested (1000 γ/ml.), the antibiotic in the muscle was more than 99.5% destroyed under these conditions and none could be found at the next longer cooking time.

**TABLE 1**

**Effect of Aureomycin in controlling spoilage of cut-up poultry dipped for 30 minutes at room temperature**

| Experiment | Concentration of Aureomycin dip | Microorganisms x $10^6$/g. Days in cold storage (3° C.) | | |
|---|---|---|---|---|
| | | 7 | 14 | 21 |
| | γ/ml. | | | |
| 1 | 0 | 9.85[3] | 23[3] | 320[3] |
| | 3 | 0.09[5] | 37[4] | 735[3] |
| | 10 | 0.03[5] | 6.2[5] | 34[5] |
| | 30 | 0.03[5] | 0.11[5] | ....[4] |
| 2 | 0 | 15[3] | 164[3] | ....[3] |
| | 3 | 3.5[5] | 40[5] | 1040[3] |
| | 10 | 0.14[5] | 5.4[4] | 28.5[4] |
| | 30 | 0.04[5] | 0.27[5] | 5.6[4] |

Legend:
[3] = Putrid.
[4] = Strong odor.
[5] = Slight odor.
[4] = Very slight odor.
[6] = No odor or slime.

**TABLE 2**

**Effect of temperature on the amount of Aureomycin absorbed by chicken breast muscle from 100 p.p.m. solution**

| Dipping temperature | Dipping time in minutes | Aureomycin remaining in muscle |
|---|---|---|
| | | γ/g. |
| 3° C. | 5 | 27 |
| | 15 | 45 |
| | 30 | 55 |
| | 60 | 88 |
| 26° C. | 5 | 27 |
| | 15 | 31 |
| | 30 | 37 |
| | 60 | 53 |
| 37° C. | 5 | 14 |
| | 15 | 18 |
| | 30 | 20 |
| | 60 | 50 |

**TABLE 3**

**Effect of cooking on residual levels of Aureomycin in chicken breast muscle**

| Cooking temp. | Cooking time in minutes | Aureomycin remaining—γ/g. tissue | | | | | |
|---|---|---|---|---|---|---|---|
| | | 3 γ/ml. sol. | 10 γ/ml. sol. | 30 γ/ml. sol. | 100 γ/ml. sol. | 300 γ/ml. sol. | 1000 γ/ml. sol. |
| Experiment 1 | | | | | | | |
| Boiled In Water | 0 | 0.34 | 2.2 | 3.4 | 23.0 | 32.0 | 115 |
| | 5 | 0.65 | 0.11 | 0.28 | 2.6 | 1.6 | 8.0 |
| | 15 | neg. | neg. | neg. | neg. | 0.45 | 0.45 |
| | 30 | neg. | neg. | neg. | neg. | neg. | neg. |
| | 60 | neg. | neg. | neg. | neg. | neg. | neg. |
| Experiment 2 | | | | | | | |
| Roasted At 230° C. | 0 | 0.73 | 3.1 | 5.75 | 12.0 | 30.0 | 130 |
| | 5 | 0.65 | 0.33 | 0.58 | 1.9 | 3.9 | 29 |
| | 15 | 0.25 | 0.13 | 0.14 | 0.14 | 0.13 | 0.8 |
| | 30 | neg. | neg. | neg. | neg. | 0.09 | 0.3 |
| | 60 | neg. | neg. | neg. | neg. | neg. | neg. |

It was of interest to determine if the laboratory results could be extended to typical conditions in a poultry processing plant. Therefore, a large-scale trial was carried out in which Aureomycin was added as a concentrate to a cooling tank to give a final concentration of 10 p.p.m. Freshly killed and dressed chickens were added to the cooling tank and removed at 2 and 24 hours, dry-packed and shipped in sealed cartons to a poultry wholesaler where they were held under refrigeration (3° C.) for the duration of the experiment. New York dressed poultry dipped in 10 p.p.m. of Aureomycin solution for 2 hours were in satisfactory edible condition after 2 weeks (Table 4) while the untreated control birds were on the verge of spoiling (note the high bacterial count and very slight odor.) The whole eviscerated and cut-up poultry which had been processed with Aureomycin for 2 hours were in excellent condition after 3 weeks while the respective control groups were then putrid. The experiment demonstrated that the incorporation of 10 p.p.m. of the antibiotic into the cooling water used in commercial poultry processing markedly increased the shelf life of poultry and gave good correlation of results with those from laboratory studies.

The data of the third column, Table 4, indicate the amount of Aureomycin present in the breast muscle of the chickens following dipping. These quantities were adequate to exert the markedly bacteriostatic effect observed. Since this bacteriostatic effect resulted from such low concentrations of antibiotic, it is obvious that the bacterial load should be as low as possible for best results. In general, the birds immersed in solutions of

Aureomycin immediately after killing have kept better than those 1-day old, which in turn have kept better than 3-day old birds, etc. It also follows that the best of sanitary practices would add further to the effectiveness of Aureomycin.

Aureomycin was found to be the most effective among the tetracycline antibiotics for poultry preservation as is illustrated in Figure 2. Whole eviscerated poultry were dipped for 30 minutes at room temperature in a solution of the test antibiotic (10 p.p.m.) and then held at cold storage for 2 weeks. Microorganisms growing on the surface of the poultry were estimated by plate count as previously described.

**TABLE 4**
**Preservation of poultry with Aureomycin under commercial conditions**

| Type of chicken | Length of 10 p.p.m. Aureomycin dip hours | Aureomycin content of muscle γ/g. | Microorganisms x $10^6$/g. Days in cold storage (3° C.) 7 | 14 | 21 | 28 |
|---|---|---|---|---|---|---|
| N. Y. Dressed | 0 | .... | 0.104[5] | 201[5] | 1250[1] | 1655[1] |
| | 2 | 1.1 | 0.010[5] | 0.047[5] | 2.76[4] | 17.5[3] |
| | 24 | 2.0 | 0.005[5] | 0.047[5] | 0.96[4] | 9.4[3] |
| Whole Evis. | 0 | .... | 0.138[5] | 1390[2] | 5400[1] | 3500[1] |
| | 2 | 1.3 | 0.004[5] | 0.77[3] | 10.7[3] | 134[2] |
| | 24 | 2.9 | 0.001[5] | 1.85[5] | 1.95[5] | 10[3] |
| Cut-up | 0 | .... | 0.375[5] | 787[4] | 2845[1] | 7150[1] |
| | 2 | 1.1 | 0.002[5] | 0.27[5] | 14.6[5] | 275[3] |
| | 24 | 3.9 | 0.001[5] | 0.012[5] | 0.78[5] | 23[5] |

Legend:
[1] = Putrid.
[2] = Strong odor.
[3] = Slight odor.
[4] = Very slight odor.
[5] = No odor or slime.

Terramycin[*] oxytetracycline and Achromycin[4] tetracycline were not as effective in extending the shelf life of the poultry, judged organoleptically, as Aureomycin. After 7 days and 14 days the number of microorganisms on the flesh of poultry treated with Aureomycin was considerably less than the numbers of organisms growing on poultry treated with Achromycin or oxytetracycline.

## DISCUSSION

The shelf life of poultry was significantly extended both in the laboratory and under commercial conditions by immersing poultry in a dilute solution of Aureomycin (3-30 γ/ml.). It is logical that a broad spectrum antibiotic should be effective against spoilage in view of bacteriological studies with poultry that have shown *(12, 13, 14)* the diversity of the microflora abounding in chicken meat and associated with odors and slime. The data of Figure 1 illustrated that Aureomycin was unique out of a number of antibiotics tested in controlling the growth of the microflora of spoiling chicken. In other investigations concerning the preservation of fish and meats with antibiotics *(7)* it was concluded that Aureomycin was more effective in preserving such foods than any of 14 other antibiotics studied; this conclusion was borne out in the present study with poultry.

An antibiotic for poultry preservation should be readily absorbed into the flesh such that dilute solutions can be used and bacteriostatic amounts of antibiotics be obtained in the meat. In the experiments of Table 4 when poultry were dipped for 2 hours in a 10 p.p.m. solution of Aureomycin, bacteriostatic amounts of antibiotic (about 1 γ per g.) were demonstrated in the breast muscle. Increasing the concentration of Aureomycin in the dipping solution (Table 3, line 1) or increasing the time of exposure of the poultry to the antibiotic solution (Table 2, Table 4) increased the uptake of Aureomycin. A number of unpublished experiments have indicated that poultry spoilage may also be retarded by storing poultry in flake ice containing a few p.p.m. of Aureomycin.

The data of Table 3 illustrated that Aureomycin in poultry meat was readily destroyed by conventional cooking procedures even when the meat was dipped in Aureomycin solutions 30-100 times higher than amounts that would appear practical for commercial extension of shelf life. During the course of the present work many chickens processed with Aureomycin have been cooked under varying conditions in a local cafeteria and microbiological assays of the meat have failed to detect any Aureomycin. Numerous taste panels have failed to detect any significant taste differences in chickens

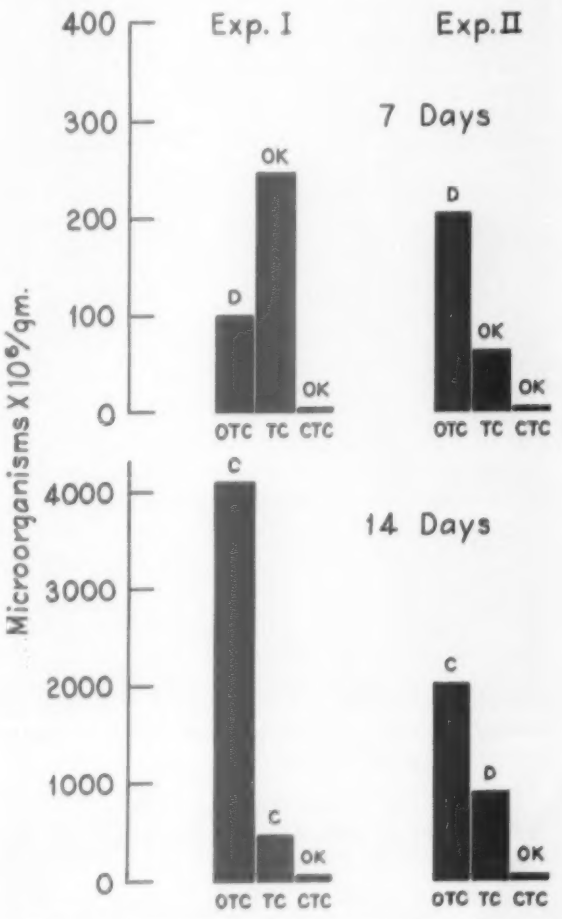


**Figure 2. Comparative effectiveness of tetracycline antibiotics in poultry preservation.**
CTC = chlortetracycline
OTC = oxytetracycline
TC = tetracycline
C = Slight odor
D = Very slight odor
OK = No odor or slime

[*] The trade-mark of Chas. Pfizer & Co. for the antibiotic oxytetracycline is Terramycin.

[4] The trade-mark of the American Cyanamid Company for the antibiotic tetracycline is Achromycin.

dipped in solutions containing 1 to 100 p.p.m. of Aureomycin compared to untreated chickens. The ease with which Aureomycin in chicken meat is destroyed by cooking is to be expected from reports *(17)* of the lability of Aureomycin to heat. At pH 7.0 Aureomycin (10 γ per ml. solution) was 98% destroyed by heating at 100° C. for 15 minutes; Aureomycin was more readily destroyed by heating than were oxytetracycline and Achromycin.

The finding that poultry processed with Aureomycin had a lower bacterial count than did poultry processed with oxytetracycline and Achromycin (Figure 2) was of interest. It is possible that certain spoilage microorganisms predominate in poultry that are less sensitive to oxytetracycline or Achromycin. In this respect Goldberg *et al. (4)* noted that of 92 microorganisms isolated from beef tissues, Aureomycin was effective over the broadest bacterial spectrum.

## SUMMARY

When microorganisms growing on the surface of spoiling chicken were plated out on nutrient agar containing various antibiotics, Aureomycin chlortetracycline was the only antibiotic out of nine others tested that was effective in suppressing growth of the organisms. Aureomycin was readily absorbed into chicken breast muscle by briefly immersing the tissue in concentrations of antibiotic ranging from 3 to 1000 p.p.m.; the amount of Aureomycin absorbed was roughly proportional to the concentration of antibiotic employed. Increasing the time of exposure to the antibiotic solution gave higher tissue concentrations. More Aureomycin was found in the tissue when the dipping treatment was carried out at 3° than at 23° or 37° C.

When cut-up poultry were dipped for 30 minutes in dilute Aureomycin solutions (3, 10, or 30 p.p.m.), such poultry remained fresh and edible with a lowered bacterial count significantly longer than untreated controls. When poultry was immersed for 2 hours in a cooling tank containing 10 p.p.m. of Aureomycin at a commercial processing plant, whole eviscerated or cut-up chickens were still in a satisfactory condition after three weeks commercial storage (3° C.).

Residual Aureomycin present in the meat of poultry dipped in solutions of Aureomycin was readily destroyed by conventional cooking procedures even when solutions of Aureomycin 100 times higher than necessary for preservation were employed.

Aureomycin was found to be more effective than either oxytetracycline or Achromycin in controlling the number of microorganisms growing on the surface of poultry during cold storage.

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Why? Because

**Florasynth's**
**STRAWBERRY IMITATION SPECIAL**

is so amazingly faithful a reproduction of nature's best. Its long-lasting, highly effective and, of course, economical utility is assurance of your product's success . . . Indeed a credit to the skill of our flavor craftsmen.

*Again . . . we say, prove its advantages to yourself . . . Sample upon request . . .*

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# Eastman offers widest range of antioxidants

If your food product needs protection against rancidity, bad odor or off-flavor caused by oxidative deterioration, Eastman can help you.

Eastman is the leader in food-grade antioxidants. The leader in volume . . . in experience . . . in accumulated data.

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The effectiveness of Eastman recommendations and Eastman Tenox antioxidants has been proved on the following products:

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| Animal Fats and Oils | Cosmetics |
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Don't let rancidity cause returns, losses and dissatisfied customers. Look into the simple remedy of antioxidants. Their cost is low.

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*For more information about Tenox, write to Eastman Chemical Products, Inc., Kingsport, Tennessee—a subsidiary of Eastman Kodak Company.*

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# URGENT: To all frozen food processors

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This is a full-rate Telegram or Cablegram unless its deferred character is indicated by a suitable symbol above or preceding the address.

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W. P. MARSHALL, PRESIDENT

FX-1201

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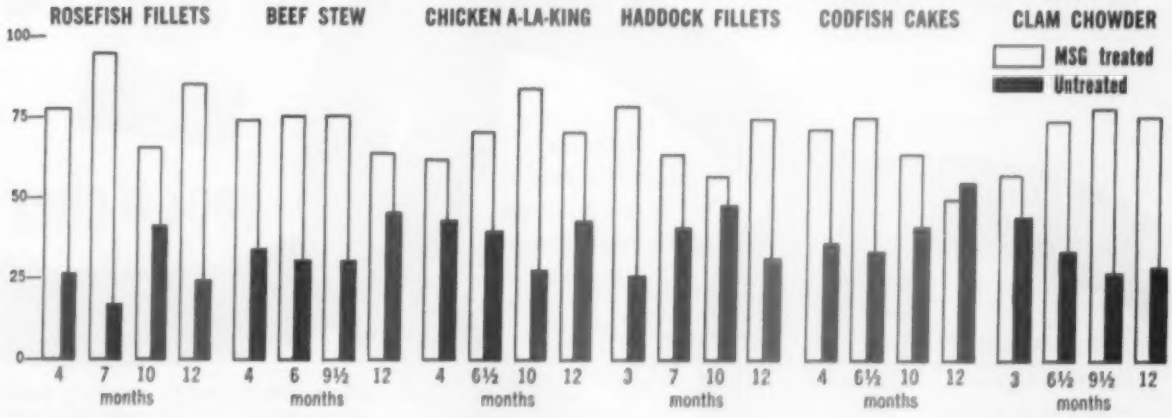
FLASHING YOU RESULTS OF 12-MONTH FLAVOR TEST OF MSG-TREATED FROZEN FOODS VS UNTREATED FOODS AT A LEADING UNIVERSITY* STOP 23 OF 24 TASTE TESTS SHOW MAJORITY OF TEST PANEL PREFERRED FLAVOR OF MSG-TREATED SAMPLES TO UNTREATED SAMPLES STOP. NOTE MORE THAN 2 TO 1 PREFERENCE IN 13 OF THESE TEST PERIODS STOP TEST ALSO REVEALED MOST EFFECTIVE USE-LEVELS FOR MSG STOP PROMISES NEW OUTLOOK FOR STORAGE AND WAREHOUSING PROBLEMS, HOLD-OR-SELL, AND PRODUCTION PEAKS AND VALLEYS STOP YOUR COPY FULL REPORT WAITING AT HURON TECHNICAL SERVICE, 9 PARK PLACE, NEW YORK 7, N. Y. STOP WRITE, WIRE OR PHONE TODAY STOP=

**Graphs show percent of test panel preference during 12 months' storage. Flavor tests conducted by university technicians.** *Name on request




B.4.10

# Huron MSG

PURE MONOSODIUM GLUTAMATE 99+%

**Made by the American pioneers in protein derivatives**

FACTORIES: Harbor Beach, Michigan

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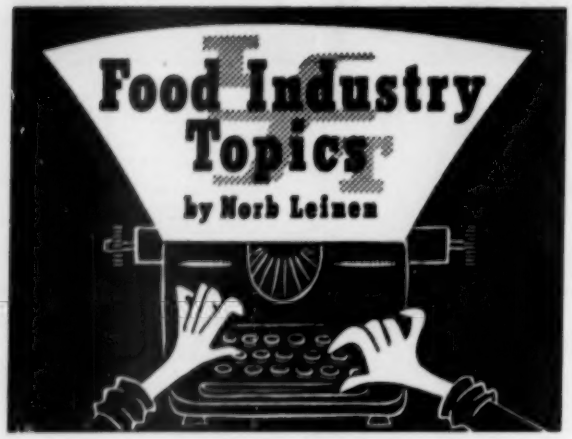


***. . . in the public interest***

Food prices will remain stable in 1955 or be slightly lower over-all for the same foods, according to Mr. John A. Logan, president, Nat'l. Assn. of Food Chains. "Naturally," he stated, "prices of most foods depend on farm prices. Some farm prices may be up slightly, some down, but over-all the level should remain about the same for the coming year. Competition, which influences retail prices, is expected to be even more keen in 1955, so consumers can look forward to good values. Prices now are down about 5% from their 1952 peak, take-home pay is at a record level, and people are eating better for less."

◆ ◆ ◆

A fund of $291,000 for grants to universities and colleges to help improve the teaching of science and mathematics was announced by the Du Pont Company as part of its $800,000 aid-to-education program for 1955-56. There are three separate parts to the support of teaching phase of the program: (1) $75,000 for summer and winter fellowships for master's degree training for high school science and mathematics teachers; (2) $125,000 to advance the teaching of chemistry in 50 privately-supported institutions; and (3) $91,000 for 24 postgraduate teaching assistantships in chemistry.

◆ ◆ ◆

The pickle, that humble but tasty tidbit, is really in the big time, outselling all other canned fruits and vegetables. The Nat'l. Pickle Packers Assn. reports that in 1954 Americans consumed an estimated 30 million cases of dills, sweets, sours, relish, and 32 other varieties of the green pickled cucumber.

◆ ◆ ◆

Mr. Percy C. Magnus, president, Magnus, Mabee & Reynard, Inc., international essential oils firm, foresees a prosperous 1955. "It is reported," he states, "that inventories are at a low ebb. Buyers have been instructed to be somewhat more optimistic as to prices

(Continued on page 30)


**Is a link missing in your Quality Control Chain?**

**cook chex**

**But he can *be prepared* in advance to spot the trouble *the moment it occurs* by using**

**No Food Technologist can tell *in advance* when a batch is going to "go bad."**

**...MPERATURE SPECIFICATIONS FOR FREE COOK-...ATORS CUSTOM-MADE TO FIT YOUR REQUIREMENTS**

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Without obligation, please send me a supply of COOK-CHEX indicator tags designed for use at _____ degrees F., for _____ minutes.

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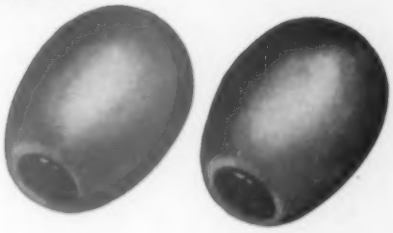
# Olives look and taste better

## in clear, pure brine.



## That's why olive packers

## should use Morton '999'

**Olive packers need Morton '999' Salt to prevent quality variations. So do makers and processors of candy... beer... canned foods ... cereals... seasonings... meat... malted milk... mayonnaise... margarine... sauerkraut.**

**MORTON '999' SALT insures uniform quality** in processed foods for two reasons. It's guaranteed to contain more than 99.9% pure sodium chloride—*always!* The 0.1% (or less) is a neutral inert sodium salt—never bitter calcium or magnesium compounds.

Vacuum pan evaporation assures that this salt will be clean ... free-flowing... evenly soluble. It has a constant weight per volume ratio . . . won't pack down.

**MAIL COUPON FOR FURTHER DETAILS TODAY!**

**MORTON '999'**

**THE SALT THAT CARRIES ITS OWN GUARANTEE**

**MORTON SALT COMPANY**
Industrial Division, Dept. FT-3
120 So. LaSalle St., Chicago 3, Illinois

**I should like to have a Morton representative call and give me—without obligation—more information on Morton '999' Salt and methods of using it in my product.**

Name.....

Title.....

Company.....

Address.....

City..... State.....

## FOOD INDUSTRY TOPICS

(Continued from page 28)

for future position. Basic industries feel confident. The automobile industry seems encouraged. Steel is showing a decided improvement. Building projects are more active. Our national income is greater than it ever has been. Our national production is greater. All these factors indicate we should have a good year."

◆ ◆ ◆

Peanut products will be higher in price and harder to buy in 1955 unless additional supplies of peanuts are imported to augment domestic production drastically decreased by drought conditions in southeastern and southwestern growing areas, Mr. Chas. P. Scully, president, Williamson Candy Co., Chicago, said recently at a hearing before the Tariff Commission. Mr. Scully, spokesman for the National Confectioners' Assn. (and newly named general convention chairman of the NCA 72nd Annual Convention and 29th Confectionery Industries Exposition, to be held June 5-9 at the Conrad Hilton, Chicago), revealed that the confectionery industry asks that all restrictions on importation of peanuts be removed until August 1, 1955, and that a hearing be held then to determine what restrictions, if any, should be imposed. "However," he stated, "because of the severe shortage of peanuts today in the U. S., the threat that imports might materially affect the agricultural program is no justification for import restrictions under Section 22 of the Agricultural Adjustment Act, and therefore does not exist."

◆ ◆ ◆

Demanding there be no further reduction of tariff on canned tuna, spokesmen for the American tuna industry appeared before the Tariff Commission and the Committee for Reciprocity Information. It was disclosed that Japanese imports of tuna since WW II have risen from 15% to 35% of the U. S. market, and that an even greater volume will flood the domestic market if any concessions are granted during forthcoming trade agreement negotiations with Japan. It was pointed out the domestic industry has completely lost the institutional trade to the brine pack supplied by Japan because of the price differential. Advertising-wise, it was disclosed, the American tuna industry has spent more than $50,000,000 since its inception to develop the domestic market, while Japan's advertising and promotional dollars have been none. This domestic advertising, a tuna sales and advertising manager stated, has indirectly promoted the Japanese products.

◆ ◆ ◆

The past year saw the second highest corn pack in history, and in quality the finest ever, according to Mr. John P. Kraemer, Sussex, Wis., president of Associated Independent Canners. Too much rain during the summer of 1954, however, he pointed out, limited the amount of peas to reach the canneries. It

(Continued on page 32)

ACCESSORY NUTRIENT FACTORS

*For the luxuriant growth of all lactic acid bacteria yeasts and molds assured by the use of*

EXCHANGE BRAND ORANGE SERUM AGAR #77

*(Dehydrated) a Complete Culture Medium*

| FORMULA — *Ingredients—when rehydrated on basis of 45 grams per liter of medium.* | |
|---|---|
| Orange juice serum solids | 12.6g* |
| Agar (dry basis) | 15g |
| Peptone | 10g |
| Yeast hydrolysate | 3g |
| Reducing sugars, total | 8g |
| Sucrose, total | 6g |
| Cysteine hydrochloride | 0.001g |

*Buffered with 0.2 to 0.6g $K_2HPO_4$ to provide pH 5.5 ± 0.05 after sterilization.*

**Equivalent to 100 ml 12° Brix orange juice serum.*

**STANDARDIZED** for uniformity and stability.

**POTENTIAL APPLICATION**—Orange Serum Agar as an all-purpose medium has a wide application to the bacteriologist and microbiologist in the milk, fruit pickling, food, bottling and fermentation industries.

Available in 1 lb. bottles through your laboratory supply house.

**Sunkist Growers**

PRODUCTS DEPARTMENT

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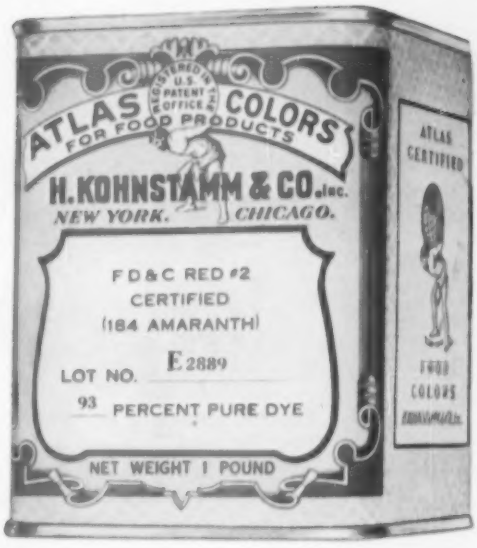
PHARMACEUTICAL SALES • ONTARIO, CALIFORNIA

# ATLAS CERTIFIED COLORS




## INDUSTRY'S STANDARD FOR 104 YEARS

H. Kohnstamm & Co., Inc. produces every color in the rainbow... just the right color to enhance your products with exciting eye and buy appeal.

ATLAS Certified Food Colors, in powder, paste and cube form have *superior solubility, incomparable brilliance* and *dependable uniformity*. No wonder they have been the industry's standard for a hundred and four years.

You should send for a copy of our booklet for reference as it contains valuable information that will be helpful to you in coloring your products. Also remember that our research facilities and staff of color experts are available for consultation at all times.

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FIRST PRODUCERS OF CERTIFIED COLORS

**KOHNSTAMM & COMPANY Inc.**

ESTABLISHED 1851

89 PARK PLACE, NEW YORK 7 • 11-13 E. ILLINOIS ST., CHICAGO 11 • 2632 E. 54 ST., HUNTINGTON PK., CALIF.
BRANCHES IN OTHER PRINCIPAL CITIES OF THE U. S. A. AND THROUGHOUT THE WORLD

*Diamond Crystal Alberger Salt is*

# America's largest-selling High-Grade* salt

*because...*

the exclusive Diamond Crystal Alberger System produces:

**Purity**—99.95% Sodium Chloride.

**Uniformity**—maximum purity variation ±0.01% . . . screened to a standard for each food product.

**Cleanliness**—lowest insolubles of any commercial grade of salt.

**Low heavy metals**—less than 1.5 part per million of pro-oxidants copper or iron.

** The premium grade salt used by food processors.*

**FOOD TECHNOLOGIST AT YOUR SERVICE**

For free consultation on choice and application of the right salt for your food products—call, wire or write:

**Technical Service Dept. B**
**Diamond Crystal Salt Co.**
**St. Clair, Michigan**
**Phone—296**



(Continued from page 30)

is feared by the industry that some of the 50 items of peas usually available the year 'round will be exhausted before many months. The quality, according to Mr. Kraemer, is as fine as ever, and the price should remain firm throughout the year.

◆ ◆ ◆

The beer can—20 years old on January 24—hit an all-time production high for the industry of nearly 6.5 billion units in 1954, according to Mr. Wm. C. Stolk, president of American Can Co. "Since January 1935, when American Can introduced the first beer can, trademarked 'Keglined'," he stated, "the entire industry has produced a total of 42 billion cans for beer and ale." He pointed out that the 200-million-unit increase in beer cans last year over 1953 was obtained despite a drop in the over-all packaged beer market, further emphasizing the growing consumer demand for the one-trip "convenience" type of container. "Packaged beer represents 77% of all beer sold," Mr. Stolk said, "and canned beer makes up 33% of this total. This swing away from draught beer— which had 75% of the market two decades ago —to bottles and canned beer fits into the nation's efficient and economical mass-merchandising habits."

Mr. Stolk also announced that Dr. R. H. Lueck, formerly general manager in charge of Canco's research and technical department, has been elected vice president in charge of the department. The scientist, with the firm for 32 years, will continue to make his headquarters in New York City.

◆ ◆ ◆

Abbott Laboratories expressed astonishment that the Food and Drug Administration publicized a National Research Council report on artificial sweeteners without referring to Sucaryl research now in progress. The firm produces the non-caloric sweetener Sucaryl (cyclamate) for use in special low-calorie foods and beverages. The company said that results of the major part of a recent clinical investigation were being tabulated when the FDA released the report to the press. " It is regrettable the agency did not see fit to request information on the current status of the project, especially since FDA officials knew the data would have a major bearing on the inferences to be drawn from the NRC report. As promptly as these data are analyzed, results will be transmitted to FDA. Meanwhile, assurance is gained from the consumption of about 200 million bottles of Sucaryl-sweetened beverages and billions of tablets over the past four years—without any reports of ill effects."

◆ ◆

LockPrime, a **corrosion-resistant liquid primer** for new or corroded steel surfaces developed by Pennsylvania Salt Mfg. Co., 1000 Widener Bldg., Philadelphia 7, Pa., offers excellent resistance to undercutting by corrosion when cover coats are mechanically damaged. On either sand-blasted new steel or wirebrushed rusted steel, LockPrime forms a tight adherent bond to the surface and provides excellent adhesion for following top coats of Pennsalt NeoCoat (liquid neoprene) or Pennsalt Thickcoat, a chlorin-

(Continued on page 34)

more flavor goes in
more profit comes out
when you use KNICKERBOCKER CINNAMON
Natural spices, the smallest part of your product, are the biggest factor in flavor. You can't take risks with flavor—and to be assured of the uniformity that means day-to-day acceptance by your trade, depend on Knickerbocker Cinnamon and other natural spices.
Knickerbocker control, from native source to final processing, gives you quality *plus* economy . . . for you actually get more flavor from less spice when you use Knickerbocker.
AMERICA'S *LARGEST* AND *MOST COMPLETE* STOCK OF CINNAMON
● *sold thru leading brokers and supply houses coast to coast*
KNICKERBOCKER SINCE 1842
SPICES
imported—processed by Knickerbocker Mills Co.
601 WEST 26TH STREET, NEW YORK 1, NEW YORK

*the greatest advance in meat seasoning*

Scientifically manufactured MAGNA SPICE CONCENTROLS have modernized the seasoning of meats by making available the true flavor components of herbs and spices in the most concentrated form known to Science . . . yet easily processed in your own plant. All the flavor is released immediately. Each batch of your product is uniformly and identically seasoned.

- Out perform crude herbs and spices.
- Easy to measure — easy to mix.
- No spoilage.
- Cut seasoning costs up to 40%.

Write for the new MM&R booklet — "The Greatest Advance in Meat Seasoning."

MAGNUS, MABEE & REYNARD, INC.

*Since 1895 • One of the World's Greatest Suppliers of Essential Oils and Flavors*

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## FOOD INDUSTRY TOPICS

(Continued from page 32)

ated alipathic hydrocarbon. It is equally effective in acidic and organic atmospheres. As a basic component of the Pennsalt NeoCoat-Thickcoat system, LockPrime is available in one gallon can and five gallon drums.

◆ ◆ ◆

Sili-Kool, a **long-lasting, economical, heat-and-weather-resistant "wonderpaint,"** developed by C. H. Dragert Co. of Dallas, Tex., and formulated of silicone and atomized silver aluminum, is money-back guaranteed to resist up to 1600 degrees while repelling rust and corrosion under severest weather conditions. Dragert chemists found that a single coat will thoroughly protect for more than a year the hottest stacks, blistering boilers, steam pipes, diesel and gas engines, exhausts, manifolds, and mufflers, irrespective of temperatures and exposure. Sili-Kool is packed in pints ($1.60), quarts ($3.10), and gallons ($12), f.o.b., Dallas, Tex. Free sample is available from manufacturer, P.O. Box 5092, Dallas.

### *. . . things new under the sun*

**Growth factors in orange juice** have proved to be dramatically successful in improving detection of bacteria, yeast, and molds. Using low temperature techniques developed for the production of penicillin and other wonder drugs, researchers at Sunkist Growers, Los Angeles, Calif., have created a dehydrated culture medium containing juice serum. This medium, known as Orange Serum Agar, furnishes essential vitamins and other organic growth factors necessary for development of bacterial strains ordinarily difficult to cultivate. Several years' testing by researchers in universities and experiment stations show that the product contains trace nutrients that make it versatile in examination of many difficult laboratory problems.

◆ ◆ ◆

In May, 1954, the USDA Meat Inspection Division amended existing regulations on use of antioxidants in animal fats, reducing the total amount of any one phenolic antioxidant which could be used in an animal fat from 0.02% to 0.01%. However, a total of 0.02% of all antioxidants was allowed and, since that time, processors have experimented with various combinations to reduce the amount of antioxidant in fats and oils, yet retain effective stability. Eastman Chemical Products, Inc., Kingsport, Tenn., after experimenting with and testing more than a dozen combinations of BHA and BHT, believes it now has, in its new product TENOX VI, the **best formulation of BHA and BHT** available for use by processors of lard, shortening, and similar food-grade products. The new antioxidant, a mixture containing 10% TENOX BHA, 10% TENOX BHT, 6% TENOX Propyl Gallate, and 6% citric acid, is dissolved in an oil soluble combination of propylene glycol, glyceryl mono-oleate, and corn oil, and offers protective properties much greater than possible from the simple addition of the two antioxidants.

◆ ◆ ◆

A machine so versatile it fills several varieties of Mexican foods from tamales to prefried beans has been

developed by F. L. Burt Co., 571 7th St., San Francisco. Though compact, the unit fills from 15 to 30 bottles, jars, or cans per minute and is adjustable from one to 32 ounces. The machine is quickly and easily cleaned, and handles both liquids and semi-solids.

◆ ◆ ◆

**A completely transparent coverall lid** formed from 10 mil Polyflex is being offered the trade by the Dixie Cup Company for use with 8-, 12-, and 16-ounce food containers. Developed by Plax Corp., Hartford, Conn., the lid is of pure polystyrene and is odorless, imparts no taste to food, is dimensionally stable, and permits a clear view of the contents. A special Plax process overcomes the brittleness normally associated with polystyrene. The lid's temperature range permits use in freezers and withstands heat used in packaging foods in waxed containers. The coverall forms a completely sanitary seal, has a high gloss, can be printed by the analine, silk screen, or hot stamp processes, and can be embossed during forming. For further details write The Charles Brunelle Co., 15 Lewis St., Hartford 3, Conn.

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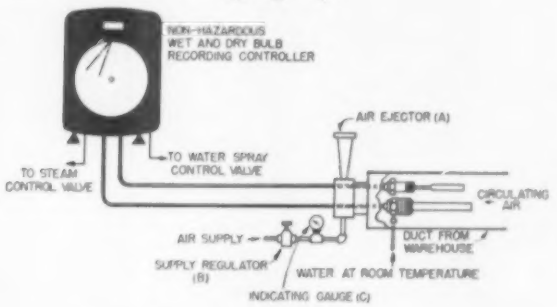



▲ — 20 PSI AIR SUPPLY

**Where a wet bulb humidity instrument is used for measurements in a hazardous area and the expense of explosion-proofing presents a problem, the wet bulb can be placed in a simple metal housing and a small air ejector used to draw an air sample over it without use of a blower. As diagrammed, the wet and dry bulbs of a Foxboro Humidity Recorder (or Controller) are enclosed in a small length of stove pipe, one end open to the hazardous area and the other connected to the air ejector. Operated by air from the plant's compressor, the ejector pulls a continuous sample over the bulb for the humidity measurement. An air supply regulator and gauge provide the necessary adjustments. The housing is easily constructed by a tinsmith, using commonly available materials, and makes it unnecessary to use an explosion-proof blower. The instrument is specified with a spring-wound instead of an electrical chart drive and can be safely located in the danger zone. Application engineering data will be sent on request by The Foxboro Company, Foxboro, Mass.**

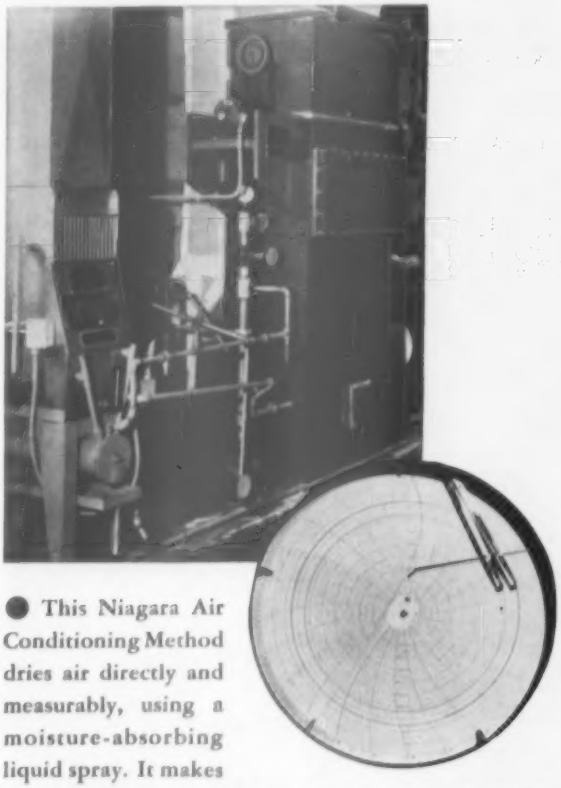
◆ ◆ ◆

**A 580-gallon, all-welded brining tank made of Inconel** to furnish unusual resistance to pitting, manufactured by F. H. Langsenkamp Co., Indianapolis, Ind., is described as the first of its kind ever made of Inconel by the International Nickel Co., Inc., 67 Wall St., New York 5, N. Y. In addition to its resistance to pitting in the presence of brine and vinegar, Inconel was chosen for its ease of welding and the fact that, when proper welding procedures are followed, no sensitization or loss of corrosion resistance results, making post-heat treatment unnecessary. The unusual metal is not subject to stress-corrosion cracking in acidic chlorides.

◆ ◆ ◆

**A low-cost molded polyethylene container** with a self-sealing, spill-proof lid that needs no tape to insure a firm, tight closure is announced by Plastomatic


# EXACT CONTROL
## of Moisture Content
### To Improve Your Product or Protect Your Materials or for Processes or Tests



● This Niagara Air Conditioning Method dries air directly and measurably, using a moisture-absorbing liquid spray. It makes humidity control a separate function from lowering or raising temperatures and gives you precise control with thermostats alone; no moisture-sensitive devices are needed. You have simpler, more trustworthy, less expensive control instrumentation. Niagara precise-control installations have the best record for reliability.

Niagara Air Conditioning provides you with any temperature and relative humidity you need. Using "Hygrol" absorbent, it is not expensive to operate, saving the refrigeration commonly used to condense moisture and making re-heat unnecessary in most cases. It gives large capacity with compact, easily-maintained equipment. Ask for Descriptive Bulletins #112 and #121. Address Dept. — FT

**NIAGARA BLOWER COMPANY**

405 Lexington Ave. New York 17, N. Y.

*District Engineers in Principal Cities of U. S. and Canada*

## FOOD INDUSTRY TOPICS

Corp., Malvern, Pa. Called "Seal-Tainer," this unbreakable, flexible plastic container is available in sotck sizes from 6 to 64 ounces, and in all colors. Special sizes and shapes are also available on order. Seal-Tainers cost approximately one penny more per unit than glass containers, weigh one-sixth as much, and may be labeled, stamped, or imprinted by offset.

◆ ◆ ◆

A new corrosion-resistant, stainless steel, fume-tight **sanitary faucet** with KEL-F sealing rings, manufactured by Economy Faucet Co., 12 New York Ave., Newark 1, N. J., is described in a bulletin available from the company.

◆ ◆ ◆

The RdF Stikon line of resistance-thermometer elements has been broadened by addition of the SN-1, a new type for higher temperature applications. In common with other RdF Stikons, a temperature-sensitive grid of very fine nickel wire is bonded between two paper-thin wafers of insulating material. Silicone-impregnated glass-fiber fabric used in the SN-1 permits continuous operation at 500° F., and short-term use at 600° F. RdF Stikons can be attached by means of appropriate cements to almost any surface anywhere. Unaffected by shock or vibration, the element will indicate temperature and temperature changes with a delicacy and speed unheard of in conventional resistance thermometers. The change in resistance with temperature may be used to actuate direct-reading indicators, recorders, or controllers of various types. Also, as is often done in laboratory set-ups, temperature may be determined by direct measurement of the element resistance by means of a Wheatstone bridge. For further information on the SN-1 and other RdF Stikons, write for Bulletin T-54 to Ruge-De Forest, Inc., 50 Moulton St., Cambridge 38, Mass.

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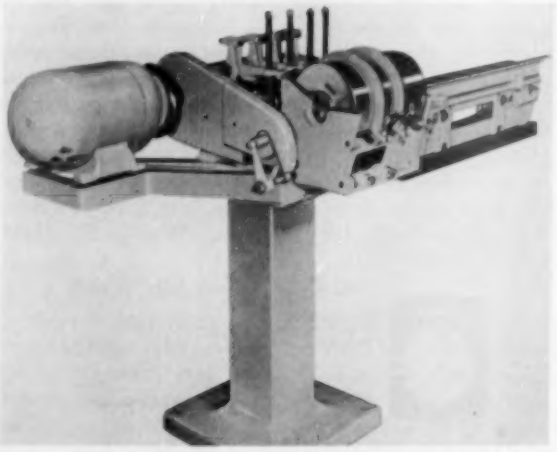


**New and improved models of its food equipment were displayed by Food Machinery and Chemical Corporation's Canning Machinery Division at the recent Nat'l. Canners' Show in Chicago. Featured were: an improved Model 3A Corn Cutter featuring a new precision gauging mechanism and cutting head that provide greater product yield while reducing maintenance and operating costs; a new FMC High-Speed Syruper incorporating an "in motion" timing device to provide an improved method of synchronizing can transfer points; a French Style Bean Slicer that is capable of increasing the capacity up to 200% over conventional preparation methods of bean slicing; a 20-Pocket M&S Filler, unsurpassed in speed, accuracy, and the range of products handled; a new model 15-Station Pea and Bean Filler; and a new and extremely efficient Sliver and Nubbin Eliminator for French-fried cut potatoes. With slight modification, the last-named machine does double duty as a Cut String Bean Sizer. The firm's sales offices are located at San Jose, Calif., and Hoopeston, Ill. Above—Model 3A Corn Cutter.**

◆ ◆ ◆

**A clear plastic cylinder** has been added to the line of compressed air Sta-Dri Oil & Moisture Separators manufactured by Beach Precision Parts Co., 120 Mechanic St., Boonton, N. J. The new clear-view unit, Model No. 65 C, is 2½" in diameter x 12" long. The plastic cylinder walls are of ¼" thickness and tested to withstand pressures in excess of 600 pounds. Model 65 C is designed for use on compressed air lines up to 250 pounds pressure. Approximate cleaning capacity of the two silk encased filters in each Sta-Dri Separator is a million cubic feet. Purpose of the transparent cylinder is to show when the filter elements should be replaced or when the moisture should be drained from the bottom of the separator. The unit will sell for under $50, with two filters of specially-treated cellular material. Other models in the Beach Sta-Dri line range from $20.50 to $155 for compressed air cleaning capacities of approximately 500,000 to 4,000,000 cubic feet.

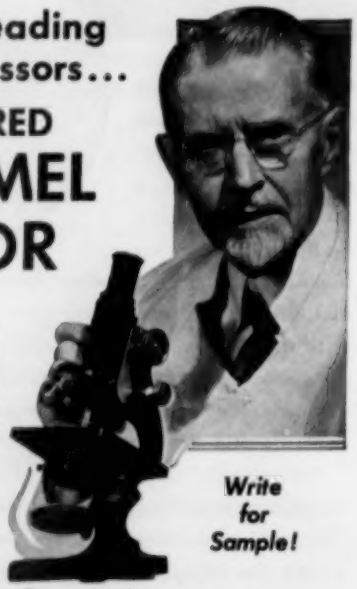
◆ ◆ ◆

Excellent promise as a brand-new candy ingredient is shown by Cransweets—**whole, sweetened, preserved cranberries** which retain their natural color and char-

(Continued on page 38)


**Used by Leading Food Processors...**

**POWDERED CARAMEL COLOR**



**A dehydrated food color, made entirely from dextrose sugar by cooking under controlled conditions.**

**It has particular use in dry food products where the use calls for a natural color ranging from a light to a very dark brown. For example:**

*Write for Sample!*

*Powdered Desserts* — *Dehydrated Soups*
*Dry Cake Mixes* — *Bouillon Powders*
*Powdered Coffee & other beverages*
*Powdered Gravy Seasonings*

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39
In 1939, to Professor Ruzicka the Nobel Prize for his work on polymethylenes and higher
In 1951, to Dr. Eddy Lederer, the award of the American Chemical Society.
55
51
53
In 1955, to Dr. Hans Schlatt, the award of the American Chemical Society.
In 1953, to Dr. Max Stoll, the award of the American Chemical Society.

*an award . . an award . . an award*
*and now another award*
*to a member of the research staff*
*of Firmenich*

The harmonious coordination of industrial and scientific research, originally established by M. Philippe Chuit and Professor Ruzicka and carried forward by Dr. Max Stoll and his associates, has borne much fine fruit in the field of organic synthetics for perfumes and flavors. So these distinguished citations—the Nobel Prize and the awards of the American Chemical Society under the Fritzsche grant—bear witness. So does the increasing preference for Firmenich products as it is expressed by customers throughout the world.

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## FOOD INDUSTRY TOPICS

(Continued from page 36)

**A new reaction-distillation pilot plant,** Model No. 611, was announced recently by Patterson-Kelley Co., East Stroudsburg, Pa. Made up of a liquid reactor, agitator, condenser, and decanter, the new unit can be used to test and study hundreds of chemical processing operations. Design features include vertical gas-injection, flexible condensate flow arrangement, and additional connection in top head to permit manifold piping arrangements or installation of other auxiliary equipment. Both endothermic and exothermic reactions, under pressures up to 150 psig, may be carried out with the unit.

* * *

Development of **instant orange and grapefruit juice as soluble crystals** marks the successful end of decades of search for a feasible method by research workers throughout the world. Chemical constituents in orange and grapefruit juices hold onto water tenaciously, and it was early discovered that if enough heat alone were applied to drive off the water it damaged the fruit, with consequent flavor loss. Engineers of the Vacu-dry Co., Oakland, Calif., along with personnel of Chain Belt Co., Milwaukee, Wis., Western Utilization Research Branch, USDA, and QM Food and Container Institute, discovered that by conducting the concentrating process under an extremely high vacuum with a *controlled* quantity of heat applied for short and controlled limits of time, water could be almost totally removed from the citrus juice in the absence of air, thus eliminating problems of oxidation or flavor impairment, and problems of storage life. The critical limits, and the methods of continuously controlling them, are part of the basis for Vacu-dry patents surrounding the successful development. It was further found that drying juices by any method, whether to frozen concentrate or dry crystals, inevitably stripped out certain essential flavors and oils. In order to restore fully those flavors and oils to the crystals, an additional technique was devised for entrapping them in a solid absorbing medium, which was then granulated. The granulated absorbent was then added to the citrus crystals in the proper proportion (not more than one per cent of the total) so that when reconstituted in water as juice the original flavors and essential oils were released. This continuous drying method also retains at least 96% of the original vitamin C content, along with other important nutritive values

of the fresh juice. For commercial production, exclusive rights to the new method have been granted in Florida to Orange Crystals, Inc., with the first plant at Plant City. Commercial production was begun recently on a year-round basis in the company's new $350,000 plant, with initial output at the rate of 2,000,000 pounds of orange crystals annually, or the processing equivalent of 15,000 fresh oranges an hour. Additional processing units will be built through 1955 and following years.

◆ ◆ ◆

**New, remote-control, waterproof electronic switches** which automatically cut off power when stoppage occurs at any point, thus preventing production line jams and back-ups, are now available in small, compact, easily installed units. Line flow is resumed automatically when the trouble spot clears since electronic impulses control motor starters at all vital points. Installation is applicable on any line conveying metal or metal-spotted objects. The switch principle, also convertible as an electronic counter, may be mounted a considerable distance from the line and is available with metal or non-conductive reinforced fiberglass cases. The switches effectively reduce personnel requirements. Write Dudley Machinery Corp., P. O. Box 397, Mountain View, Calif.

### . . . *the literary corner*

Just issued—the latest wholesale price list of Fritzsche Brothers, Inc., 76 Ninth Ave., New York 11, N. Y., covering Essential Oils, Sesquiterpeneless and Terpeneless Oils, Citrus Concentrates, Floral Absolutes, Floral Concretes, Aromatic Chemicals, Floral Waters, Animal and Resinoid Fixatives, Tinctures, Oleoresins, Colors, and Balsams, Gums, and Sundries. Availability limited to those whose purchases are in wholesale quantities.

◆ ◆ ◆

The December 1954 issue of *Newscast*, published by Cooper Alloy Corp., Hillside, N. J., is partially devoted to "The Why and Wherefore of Vacuum Drying," and also points up some valuable "do's" and "don't's" with regard to ordering, installing, and operating filters.

◆ ◆ ◆

According to the December 15 issue of The Refrigeration Research Foundation *Bulletin*, new concepts of container function have come to the fore: for fresh produce, the concept of "microclimate," the atmosphere that protects the product and extends storage life; for frozen products, the concepts of faster freezing within the case to save costs, the control of condensation (pertinent to both frozen and unfrozen refrigerated products), and improved construction of more appropriate materials to increase "warehouseability."

◆ ◆ ◆

From M. R. Nestor, manager, Project Development, Battellé Memorial Institute, 505 King Ave., Columbus 1, O., comes a beautifully executed get-acquainted brochure on Battelle research teams and facilities, and how they can help industry solve technical problems. This one is a beauty!

*National Safety News* for December 1954, published by Midwest Research Institute, 4049 Pennsylvania, Kansas City, Mo., tells in four fact-packed pages how to minimize fire, explosion, and vapor intoxication hazards when using organic solvents.

◆ ◆ ◆

A 28-page, 2-color brochure on Hydro-Flo hot water heating products, including boosters, universal pumps, relief and reducing valves, compression tanks, comfort control systems, motorized valves, water heaters, and heat exchangers is available from Bell & Gossett Co., Morton Grove, Ill.

◆ ◆ ◆

Tubing of titanium, the promising and still comparatively new metal whose potential usefulness has just begun to be realized, is described in Bulletin 43, published by Superior Tube Co., 1697 Germantown Pike, Norristown, Pa. The 8-page bulletin, "Titanium, New Member of the Family of Metals," presents the most up-to-date information on fabrication of unalloyed titanium tubing. Subjects covered include heat treating, pickling, welding, brazing, and machining.

◆ ◆ ◆

Atomic warfare is being waged against the screwworm, reports "Industrial Research Newsletter," Vol. 5, No. 3, published by Armour Research Foundation of Illinois Institute of Technology, Technology Center, Chicago 16, Ill. USDA scientists are working with Dutch authorities on the Caribbean island of Curacao in an effort to wipe out the fly, whose mag-

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## FOOD INDUSTRY TOPICS

gots attack livestock in Florida and Curacao, causing millions of dollars loss annually. Aware that the female mates only once a year and only with one male, scientists released thousands of males made sterile by gamma rays from radioactive cobalt. Mated with a sterile male, the female's eggs will not hatch, thus reducing the population of the next generation.

◆ ◆ ◆

A new data sheet describes use of "aiROYmetric" Controlled Volume Pumps to proportion caustic soda to vegetable oil flow, thereby assuring proper break. A second proportional feed system meters activated clay in the bleach phase. Copies of data sheet B-54-1 are available from Milton Roy Co., Station A, 1300 E. Mermaid Lane, Philadelphia 18, Pa.

◆ ◆ ◆

"What's New in Food and Drug Research," December 1954, published by Food Research Laboratories Inc., 48-14 33rd St., Long Island City 1, N. Y., features such interesting titles as "Developments in Sausage Casings," "Action of an Anti-Alcohol Drug," "Puzzle in the Poultry Industry," and "There's No Accounting for Tastes."

◆ ◆ ◆

While the increase in world exports of Straits tin from Malaya, the largest producing country, was 13% in the first 11 months of 1954, over the same 1953 period, the jump in shipments to the U. S. was three times as great, reports the January issue of *Tin News*, published in Washington, D. C. (1028 Connecticut Ave.) by The Malayan Tin Bureau. Making an adjustment for the difference in the value of the dollar, the Bureau also states that the average price of tin in the first half of last year was 15% below the 1937 average. At the same time, zinc remained at its 1937 level, while lead was 12% higher and copper 13% higher.

◆ ◆ ◆

"Becco Echo" for December 1954, published by Cecco Sales Corp., sales agents for Buffalo Electro-Chemical Co., Inc., Buffalo, N. Y., is devoted to a write-up on the Lobund Institute of the University of Notre Dame. Lobund is an "initial name" for Laboratories of Bacteriology, University of Notre Dame. The Institute's major activities are three: micro-surgery for the study of single cells, the study of germs in safety cages, and the growth of germfree animals for research in nutrition, animal ills, and fundamental biology and medicine. Though not necessarily the most important activity, the animal study is the most dramatic. Current or recent projects in this area include studies of dental decay, radiation sickness, amoebic dysentery, shock, cancer, and lymphomatosis. Such projects are "applied science" and to that extent a diversion from Lobund's basic objective of pure research, which, by discerning isolated causes and effects indicates paths which other scientists and industry can follow to create broad social benefits.

◆ ◆ ◆

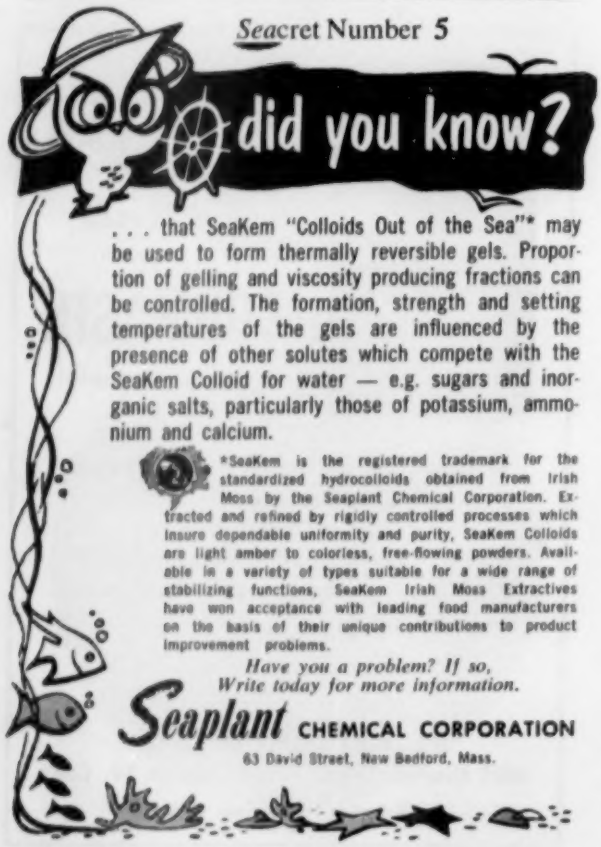
The October issue of *Newscast*, published by Cooper Alloy Corp., Hillside, N. J., contains articles on "The Newer Cost Stainless Alloys," "Designing for Sound Castings in Stainless Steel," "Shell Molding," "Factors in Designing Cast-Weld Construction." Also included in the 16-page publication is an alloy properties chart and an application data chart. For free copies, write Mr. Geo. Black at the above address.

### . . . *meeting hall and conference room*

The National Dairy Engineering Conference, to be held March 8-9 at Kellogg Center, Michigan State College, East Lansing, will feature addresses on such diverse subjects as "What's New in Equipment," "Engineering Design of Dairy Plant Floors," "Experiences with a New Type of Dairy Waste Treatment," "The Manufacture and Utilization of Dry Milk Fat," "Dollars Saved by Vehicle Sense," and "Temperature Measurement and Control for Processing."

◆ ◆ ◆

The Third Annual Food Technology Short Course, jointly sponsored by the University of Missouri College of Agriculture and the St. Louis Section of IFT, will be held on the Columbia, Mo., campus March 18-19, 1955. General theme will be "Food Additives," with four symposia sessions devoted to consideration of: (1) "Purposes and Problems of Using Food Additives," (2) "Nutritional Aspects of Using Food Additives," (3) "Commercial and Legal Aspects of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did you know?
. . . that SeaKem "Colloids Out of the Sea"* may be used to form thermally reversible gels. Proportion of gelling and viscosity producing fractions can be controlled. The formation, strength and setting temperatures of the gels are influenced by the presence of other solutes which compete with the SeaKem Colloid for water — e.g. sugars and inorganic salts, particularly those of potassium, ammonium and calcium.
*SeaKem is the registered trademark for the standardized hydrocolloids obtained from Irish Moss by the Seaplant Chemical Corporation. Extracted and refined by rigidly controlled processes which insure dependable uniformity and purity, SeaKem Colloids are light amber to colorless, free-flowing powders. Available in a variety of types suitable for a wide range of stabilizing functions, SeaKem Irish Moss Extractives have won acceptance with leading food manufacturers on the basis of their unique contributions to product improvement problems.
Have you a problem? If so,
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63 David Street, New Bedford, Mass.

Using Food Additives," and (4) "Technological Aspects of Using Food Additives." For reservations, contact Mr. C. M. Harrold, Jr., c/o Anheuser-Busch, Inc., 721 Pestalozzi St., St. Louis 18, Mo.

◆ ◆ ◆

Designed to benefit production department employees, and all superintendents, foremen, assistants, and management employees, the Ninth Annual Production Conference of The Pennsylvania Manufacturing Confectioners' Assn. will be held at Franklin and Marshall College, Lancaster, Pa., on April 28-29. For program, registration, and reservation particulars write Mr. Harry H. Rohrer, P. O. Box 163, Elizabethtown, Pa., or Mr. Hans F. Dresel, 15 Lombard St., Philadelphia 47, Pa.

***. . . building up and branching out***

Continental Can Company has signed a service agreement with Toyo Seikan Kaisha, Ltd., Tokyo, largest can manufacturer in Japan, it was announced by Mr. Lowell K. Hanson, general manager of Continental's Overseas Division. Under the agreement, the Japanese firm, represented by Mr. M. Yoshikawa, managing director, becomes a licensee to use Continental's machinery, manufacturing processes, and technical knowledge in the metal container field. Toyo Seikan has four factories located in Shimizu, Osaka, Tobata, and Tokyo. Continental has similar service agreements with other foreign container companies in more than 15 countries.

◆ ◆ ◆

Forty-two sales engineers were recently added to the field sales force of Minneapolis-Honeywell Regulator Company's Industrial Division in 25 branch offices located in 23 U. S. cities and two Canadian cities, it was announced by Mr. J. A. Robinson, field sales manager. Appointment of the new sales engineers—all graduates of the division's training school in Philadelphia—is in line with the firm's planned growth program designed to meet the increased complexities of marketing in the automation field. In addition, 18 service engineers were added to the firm's field sales force, taking positions in 12 U. S. cities and one Canadian city.

◆ ◆ ◆

Foster D. Snell, Inc., 29 W. 15th St., New York 11, N. Y., has been engaged to do research and testing for the 6,000-member American Hotel Assn. Arrangements were made in accordance with the new policy set up by the Association's Research Committee to comply with a Planning Commission recommendation. The policy requires that samples, to qualify for free laboratory testing service, be a type widely used by hotels and of a brand generally available throughout the U. S. This excludes, among others, products of foreign manufacture not widely distributed in this country, custom carpets of special design, and private brand products, such as those packaged under a special label for a hotel.

◆ ◆ ◆

The Pennsylvania Salt Mfg. Co., 1000 Widener Bldg., Philadelphia 7, Pa., announces opening of two new plants at Delaware, O., and Chicago Heights, Ill. The plants, Pennsalt's 13th and 14th, are components of the firm's Chemical Specialties Division. They will

Ultra-violet spectrophotometer provided valuable data in the development of Permaseal Flavor Crystals and is used in quality control.

**Givaudan sets a New Standard of Quality and Stability with**

**PERMASEAL FLAVOR CRYSTALS**

Givaudan's new series of Permaseal Flavor Crystals is the result of extensive research conducted to provide you with superior powdered flavors at a new low cost.

They are produced by a special Givaudan-developed cold process that prevents flavor deterioration. Coatings are made of carefully selected materials that protect the freshness of the oils, and are highly soluble.

Here are flavor crystals that offer new and unique advantages for cake mixes, instant icings and frostings, powdered ice cream and sherbet mixes, puddings and pie fillings, gelatin dessert and summer drink powders, and other flavored products sold or transported in powdered form. And because of the flexibility of this new process, Givaudan can custom-make special flavors for your particular needs.

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Chicago • Atlanta • Seattle • Los Angeles • Toronto

## FOOD INDUSTRY TOPICS

serve as blending, packaging, and warehousing centers for Pennsalt's growing specialties markets in the east-central area and are the first of a number of projected units designed exclusively for this purpose.

***. . . the human element***

Continued growth of the Chemical Division of Celanese Corp. of America has necessitated expansion of the New York sales department staff under Mr. John W. Stevens, general sales manager, it was announced by Mr. Richard W. KixMiller, Division general manager. The new position of assistant general sales manager in charge of staff sales functions has been created for **Mr. R. J. Werner,** who has been Chicago district sales manager. His responsibilities will include supervision of product managers. All district sales managers will be responsible as in the past to **Mr. Robert W. Kampschulte,** assistant general sales manager in charge of line functions of the sales department.

◆ ◆ ◆

**Dr. Berton S. Clark, former president, Institute of Food Technologists, and newly appointed director of research for the Maine sardine industry, is shown flanked by Mr. Carroll Peacock, Lubec, Me., chairman of the Maine Sardine Tax Committee (left), and Mr. Geo. Seybolt, Watertown, Mass., president of the Maine Sardine Packers Assn. Dr. Clark will maintain an office at American Can Co., Maywood, Ill., where he is retired research and scientific director, as well as at the Augusta, Me., headquarters of the association.**

◆ ◆ ◆

Mr. Miller

**Mr. John R. Miller,** late major with the U. S. Army QM Market Center System, and specialist in meat procurement, and the frozen food field, has joined the Sales and Service staff of Dodge & Olcott, Inc., Dry Soluble Seasonings Division. Most of Mr. Miller's more than 15 years of active experience in the meat packing industry has been spent with various segments of the Quartermaster Corps, handling diverse assignments in many parts of the world. He will work in and out of the D&O plant in Hawthorne, N. J., for approximately six months and then locate in Chicago.

◆ ◆ ◆

Anheuser-Busch, Inc., St. Louis, Mo., announces apointment of **Dr. R. J. Sumner** to the position of sales manager of the Dried Yeasts & Derivatives Dept., succeeding the late Mr. James D. Vernon. Dr. Sumner had been director of the brewing firm's Central Research Dept.

◆ ◆ ◆

**Mrs. Dorothy E. Laugieri,** formerly of The Fleischmann Laboratories, has joined Evans Research and Development Corp., 250 E. 43rd St., New York 17, N. Y., where she will assist in directing activities of the expert sensory panel on problems of odor and taste.

◆ ◆ ◆

**Mr. Lawrence H. Flett,** with National Aniline Div. of Allied Chemical & Dye Corp. for 35 years, retired for reasons of health from full-time active service on Dec. 31, 1954. He will continue to serve National as a consultant. Mr. Flett, for the past 12 years director of National's New Products Div., pioneered work on which the great development of synthetic detergents in the U.S. is largely based. He hold about 75 patents in the field of chemistry, and is author of a large number of publications and co-author of a number of books.

◆ ◆ ◆

Appointment of **Mr. John P. Eberhart** as manager of The Pfaudler Sales Co. of Portland, Ore., is announced by The Pfaudler Co., 1000 West Ave., Rochester 3, N. Y. The Pfaudler Sales Co. represents Pfaudler in Idaho, Montana, Oregon, Utah, Washington, and Wyoming.

## Advertisers' Index


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Appointment of **Dr. Sam R. Hoover** as head of the Hides, Tanning Materials and Leather Section at the USDA's Eastern Utilization Research Branch in Wyndmoor, Pa., has been announced by Dr. P. A. Wells, chief of the EURB. Dr. Hoover succeeds Mr. Jerome S. Rogers, who retired in November, 1954.

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**Dr. J. F. Muller** has been named general manager of the Prescription Products Dept. of the Borden Company's Special Products Division, according to announcement by Mr. Chas. F. Kieser, vice president in charge of the Division. He succeeds Harry McNeilly, who has resigned. Dr. Muller, a chemist and bacteriologist, and a member of IFT, previously was assistant general manager and has also held the post of research director.

◆ ◆ ◆

Mr. Cole

**Mr. Hubert M. Cole** has been appointed technical director of the Flavor Division of Firmenich Incorporated, 250 W. 18th St., New York 11, N. Y., international flavor house, according to Mr. Charles C. Bryan, persident. IFT member Cole assumes the duties of **Mr. W. D. Graham,** who has been assigned to the research laboratories of Firmenich & Cie in Geneva, Switzerland.

◆ ◆ ◆

**Mr. Roland S. Shumard** has been appointed director of Development and Technical Service for the Huron Milling Co., 9 Park Pl., New York City, it was announced by Mr. R. M. Farr, president of Huron. Mr. Shumard was formerly manager of Fine Chemicals Development for Monsanto Chemical Co.

◆ ◆ ◆

**Dr. Leland A. Underkofler** has joined Takamine Laboratory, Inc., Clifton, N. J., as director of Re-

## EMPLOYMENT NOTICES

**WANTED:** Chemist. Prominent shortening manufacturer can provide excellent future for college graduate in science with experience in commercial or experimental baking. Young man, under 35 yrs. of age, must be mature, stable, personable. REPLY BOX 389, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

**AVAILABLE:** Food Technologist, receiving Ph.D. in June '55. Desires responsible position in Research, Plant Manager, Quality Control or Teacher. Supporting work in all branches of Chemistry and Agriculture. Publications, Research and teaching experience. 6 yrs. practical experience with food industry. REPLY BOX 392, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

**WANTED:** Food Technologist — experienced in meat canning. New York location. Send complete resumé of background and salary requirements. REPLY BOX 391, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

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Excellent opportunity for Food Technologist or Food Chemist who is qualified to conduct product development in foods. Bachelor's Degree or higher. Experience in food research and analytical work desired but not essential. Salary commensurate with ability and experience. Send complete resumé of experience and education to:

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**WANTED:** Flavor Chemist. Midwestern city. Adequate training plus minimum 3 yrs. experience in flavor compounding. Starting salary based upon education and experience. Send resume. Not a replacement but part of planned expansion program. REPLY Fries & Fries Inc., 110 E. 70th Street, Cincinnati 16, Ohio.

**WANTED:** Food Technologist for candy factory located vicinity New York City; preferably with some experience in candy and chocolate. Send complete resumé of education and experience together with salary expected. All replies held confidential. REPLY BOX 390, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

**WANTED:** Food Technologist for control and development of chocolate syrup, table syrup, jellies, and tomato products, produced by a medium size Chicago manufacturer. All inquiries will be handled in strictest confidence. REPLY BOX 393, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

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Right man will be able to take full advantage of laboratories, literature and contacts of well-established team. Advanced degree required. Some travel. Headquarters, Metropolitan area. Salary open.

In reply state age, experience, education, and salary desired. BOX 388, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

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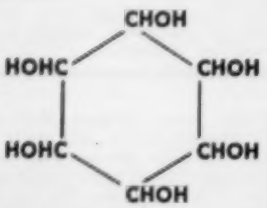


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## FOOD INDUSTRY TOPICS

search. IFT member Underkofler has been professor of chemistry at Iowa State College, Ames, for 20 years, and is well known for his research contributions to enzyme technology and fermentation industries, having published many research papers.

◆ ◆ ◆

**Mrs. Marie W. Layer** has joined the staff of Hines-Park Foods, Inc., Ithaca, N. Y., as home economist in charge of the Duncan Hines Test Kitchen, it was announced by Mr. E. L. Ackley, director of quality control and research.

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**Mr. Clayton Hayes,** formerly superintendent of the Los Angeles plant of Western Waxed Paper Division, Crown Zellerbach Corp., has been transferred to Dallas, Texas, to establish a sales office there. He will serve as resident sales representative in the Dallas area. Mr. Hayes has been associated with the firm for 17 years. Mr. Lloyd Root has been named Los Angeles plant superintendent.

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**Dr. Sidney Mittler,** research biologist at Armour Research Foundation of Illinois Institute of Technology, Chicago, has been honored for his work in studying trace elements in nutrition by being awarded the award of scientific merit presented by the Foundation's chemistry and chemical engineering research department for "outstanding individual scientific accomplishment."

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Mr. J. A. Kirkman, Jr., vice president in charge of sales and advertising of Red Star Yeast and Products Co., Milwaukee, has announced appointment of **Dr. John C. Garey,** manager of the Special Yeast Products Division of Red Star, as assistant to the vice president in charge of sales and advertising.


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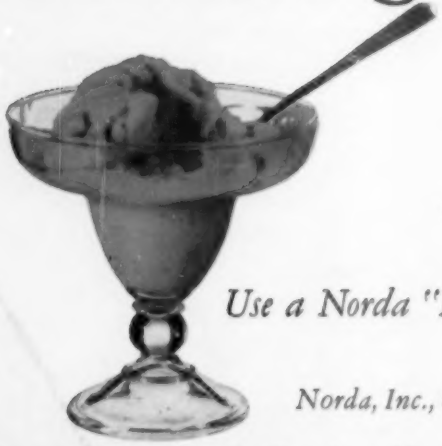

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